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OF THE

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OF

CORNWALL;

INSTITUTED FEBRUARY 11th, 1814.

VOLUME THE FOURTH.

SECOND EDITION.

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President of the Board of Agriculture.

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OF

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—	23		No. 2		No. 3
—	30		contain		contains
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188	4		blueish		bluish
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—	22		contains		contain
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312	8		independant		independent
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331	6	—	characterise	—	characterizes
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349	27	—	parts	—	part
350	2		has		have
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359	25				
362	18		their		its
364	8	—	recline	—	reclines
458	28		effected		affected
463	23		depoits		deposits

IN THE PLATES.

Nos. 2, 3, and 4. The two greens ought to have been shaded into each other as mentioned at page 384.

No. 2. The small red patches should have been of the same tint as the larger ones:—and the red colour, at Duporth, near St. Austle, ought to have been brown, denoting a magnesian rock.

TRANSACTIONS.

I.—*Some general Observations on the Structure and Composition of the Cornish Peninsula.*

By JOHN HAWKINS, Esq. F.R.S., &c.
VICE PRESIDENT OF THE SOCIETY.

(Read October, 1828.)

When a traveller is exploring his way through a new country, and has advanced to some distance from the point of his departure, he will naturally mount the first eminence within his reach, that may enable him to take a view of the unknown region which lies before him.

This, gentlemen, is precisely the situation in which we are now standing; and I propose to make the same use of it. We have entered upon the examination of a country, which, however familiar it might have been to our notice, was very imperfectly known to us; and, as some progress has now been made in our labours, it is time for us to survey the ground which we have still to pass over.

If, in the enlarged view which I propose to take of this subject, the difficulties which we have to encounter, should rather exceed the estimate which has been formed of them; I trust that they will neither abate our zeal nor weaken our perseverance; for with truth it may be affirmed, that although these difficulties seem to multiply as we advance, yet the habit of observation which has been acquired, together with the familiar acquaintance which we have now formed with the principal phenomena, have rendered them less formidable.

Our progress, indeed, has been rather irregular, and perhaps the hasty view which has been taken of some very unsettled points of inquiry, may require revision: yet all this may be very satisfactorily effected by the very authors of these communications; or at least by those who may possess more leisure, and better opportunities for observation; for it is one of the advantages which we derive from the very nature of our scientific union, that the errors or omissions of one observer may be corrected and supplied by the labours of another. Nor is the credit which is due to the first observer, materially lessened by such correction; the love of truth being presumed to have had an equal influence over both parties. It is hardly necessary for me to remind you, that in all these cases, a due regard ought to be had to the feelings of our predecessors, or to what may be called, the courtesy of literary intercourse; of which I think the French offer, upon the whole, the most commendable examples.

While I feel anxious that the objects of our combined investigation should be chiefly attained by the exertions of native geologists, for they alone have the means of revising their labours, I cannot help observing that our success will very greatly depend upon the accuracy of our conception of new facts, and on the full, clear, and candid manner in which they are reported. It will depend too upon the scientific precision which we may apply to the nomenclature both of rocks and of simple minerals: much of the confusion and uncertainty, which still prevails in geognostical inquiries, having arisen from a neglect of this precept.

Having taken the liberty of observing how much our progress and success is connected with our accurate conception of facts, as well as with their full, clear, and candid exposition; I ought to add, that the power of accomplishing this, will again depend upon the freedom which shall characterize our spirit of inquiry, or in other words, on the restraint which we are able to impose on our natural bias to hypothesis.

To avoid all conjecture on the origin of what we see, and all anticipation of facts which may have a tendency to support it, is I believe impossible; nor were it possible, would it be adviseable; for it is no other than that exercise of the mind, which leads us to the greatest discoveries of the laws of nature. More often however, it leads us to false conclusions; for as our imagination is allowed to supply all the links which are wanting in the chain

of our inductive evidence, and to mould every fact to its own form; the result is an hypothesis, which dazzling for a time, maintains its ground only until another is started.

It is some consolation to those who have the interests of science more at heart, than the gratification of their vanity, that the seductive influence of this disposition to hypothesis, diminishes as we advance in the study of nature. We are now arrived, I believe, at this stage of our progression; and I perceive with pleasure, the liberal and ingenuous spirit of inquiry which distinguishes the volumes of our Transactions.

Had the structure of Cornwall borne a close analogy to that of any other country which has been properly investigated and described, the task which we have entered upon, would have been comparatively easy; but the case is far otherwise: many of the phenomena are new: we have to record new combinations of those already known; and some of those which are either hidden from observation in other countries, or which it has been found very difficult there to investigate and describe, are here laid open to the view of the most casual observer.

Already, under the fostering influence of our distinguished President, a sufficient mass of information has been collected to prove the great importance of these objects of inquiry; but, although some credit may have been acquired by our labours, let us recollect how much of this unexplored country still lies before us.

The difficulties of observation are much too great under any circumstances, not to require the utmost vigilance and precaution, to prevent self-delusion: nor can we properly estimate the importance of any facts which may strike our attention, until the analogy which they bear to others of the same class, shall be confirmed by repeated examination. It will be sufficient, if by way of illustrating this remark, I mention the stratification of our granite; a question which is not to be settled by one or two insulated and local observations, but by many which are independent of each other; all which however must be combined with or corrected by a due attention to those circumstances which render the appearance of stratified divisions of rock masses so very equivocal. I recommend this object of inquiry more particularly to the members of this society, because it appears to me, that the means of settling this great question lie within our reach.

This, however, is not the only question respecting our granite formation, which I could wish to see decided. I have upon a former occasion, hinted at some characters which, if permanent, may in conjunction with others, enable us to draw a line of distinction between the different links of the great chain of granite hills, which runs through the peninsula: and to the attention of Cornish Geologists I farther beg leave to recommend what they alone possess the means of accomplishing,—a series of observations which shall be made with a view to ascertain the relation of these insulated masses of

granite to the strata of clay-slate which envelope or surround them. We have already noticed several instances of, what may be called, the very close geognostical affinities of these two formations. Some farther discoveries of this sort may lead us, perhaps, to more important conclusions: in the mean while I must observe that the examples of alternation which have been already published, are by no means described with as much attention to all the circumstances of their occurrence, as could be wished: for instance, there is reason to conclude that the beds of granite and of killas, in the parishes of Camborne and Illogan, overlap each other at their extreme edges; but it remains to be ascertained with what degree of regularity this takes place, in regard to the form of the overlapping masses, their extent, and their underlie. Some difficulties will attend these inquiries, but they are not insurmountable; and among the numerous individuals who direct the operations of our miners, there are doubtless some who possess all the zeal, intelligence, and perseverance that are requisite. The experience which I have had of the practical skill of this class of men, and of their natural acuteness, leads me to express a wish that every advantage may be taken of their assistance.

In the case which I have alluded to, several modes of alternation are conceivable, but much of the labour of inquiry may be diminished by directing the attention of our miners to the following points. Do the protruding masses of growan become more

frequent, or the reverse, in the deeper levels? Do they become thicker as they succeed each other in depth? Do they taper away and diminish in thickness, as they retire from the central mass of growan? Have they any regular underlie? and what is it? Has the central mass from which these masses of growan are protruded, any regular line of descent beneath the killas? and does this line conform to that of the surface of the hill above it? Lastly, what are the relative appearances of the growan, and of the killas, at the point of contact?

I shall proceed to offer a few remarks on the subject of what are called our granite lodes.

It is well known that these are not peculiar to the granite-formation of Cornwall; they have been long noticed in Saxony, Bohemia, and other countries; and they have been described, although imperfectly, by Charpentier and other writers: but I believe that no particular theory has been offered in explanation of their origin, nor indeed have they been observed with sufficient attention to justify such an attempt. As far, however, as any progress has been made in our acquaintance with these remarkable deposits, it must be acknowledged that the term lode, although convenient, is not strictly applicable to the phenomena which are characteristic of them; and it is highly probable, that when we shall have farther ascertained their nature, it will be found adviseable to select some other. I much doubt, for instance, whether these granite lodes extend far enough in any direction through the growan and killas, to be

entitled to this distinction; moreover they appear to be very capricious in their line of direction, and what is remarkable, they meet without intersecting each other. On the other hand, the same objection to the application of this term does not apply in an equal degree to the elvan-courses, which intersect the killas districts; these having been traced to great distances, and being found in one instance to intersect a tin lode. Their magnitude, however, and their great underlie, are circumstances which cannot be reconciled to our notion of true lodes.

From the occurrence of granite veins in the slate of our sea-coast, wherever the junction of the two rocks has been observed, Mr. Carne has been led to suspect, that if the lines of their junction could possibly be laid open to view, these granite veins would be seen traversing the slate at almost every point. The boldness of this conjecture has been justified by the discoveries which have been made in the deep mines of the parishes of Camborne and Illogan: for although it be true, that the alternating masses in these cases, have more the character of beds, than veins, yet there appears to have been in both cases, a reciprocating action of two distinct processes of rock formation.

Something of a nature not less singular, appears to have taken place in the formation or developement of the granite mass itself; and to have produced by a principle of attraction and repulsion, in most instances, those variations in its form and mixture, which have been called contemporaneous

granite veins. But here, I believe, we must cease to indulge in conjecture; for in the present state of physical science, and in the absence of any aid from analogy, all attempts to explain in a more satisfactory way, the origin of these singular phenomena, must prove unavailing.

The importance of the subject, however, induces me to take a more general view of our Cornish granite, and to touch upon some subjects of inquiry, which more particularly merit our attention.

Hitherto, as I understand, no examples have been met with in Cornwall, of that concentric scaly structure of this rock, which has been observed, although very rarely, in other countries; nor does the Cornish granite shew a disposition any where to assume the schistous structure of gneiss. Moreover, as far as my observation extends, there appears to be a general and consistent character in the internal structure of the mass which constitutes each group of the granite hills; although that character may so vary in the several groups of the chain, as to lead to specific distinctions.

Nevertheless, I strongly suspect that all these insulated groups of the granite formation, as they approach the circular edges of the slate, will be found to admit a considerable modification or new developement of their internal structure; and that the termination of each in this direction, will, in most instances, be announced by the same phenomena of contemporaneous veins, and the same interposition of foreign matter in the shape of floors, which

have been so well observed by Mr. Carne in the cliffs westward of Penzance. In support of which opinion I shall mention the following circumstances in the natural history of the Hensborough group, which deserve some notice; for instance, that very singular mass of shorl rock, in the parish of Roche, which covers a portion of its northern base, and occurs in various other parts of its periphery, but which I am by no means disposed to regard as an independent formation; and secondly, the celebrated porcelain granite of St. Stephens, which occurs at its western base, and together with some other small grained varieties of the same rock, which are well adapted to building purposes, tends to shew that in the termination of this process of nature, there must have been less uniformity of action, an abated energy, and something like a state of indecision.

On the other hand, the change which takes place in the structure and composition of the slate formation, as it approaches the granite, is well known; and it is easy to recognize in those mantle-like depositions, which form a girdle of stratified rocks round the base of our growan hills, both the geognostical and the oryctognostical affinities which exist between the granite, and the clay-slate or killas: the hornblende which abounds in some portions of the latter, and the feltspar or the mica which predominates in others, presenting some characters of affinity to the granite; while all these anomalous varieties of rock display a gradual transition into the killas, as they recede from the growan. It appears, there-

fore, that nature in this instance, as well as in most others, has acted, not *per saltum*, but by approximation.

Of the two formations, which spread over the greater part of the peninsula, the slate is that which is most familiar to us. It forms the basis of our best arable soil, and it is the principal seat of our mining enterprize and industry. There is no portion of it, therefore, which is unexplored. It is more particularly since the institution of this society, that our attention has been directed to the characters which distinguish it; and at this period we have a right to presume, that our knowledge of these characters is sufficiently extensive to enable us to correct the hasty judgments of some geological travellers. Thus, for instance, when we are told by Dr. Berger that *graywacké* is the predominant rock of this country, we look around us, but in vain, for some example of the type of this aggregated and derivative rock, which may have given countenance to such an assertion: every where, however, we behold in this portion of the peninsula a stratification of clay-slate, which bears all the marks of a primitive and independent origin. The very intimate connexion which we have lately discovered between the evolution and consolidation of this rock, and that of our granite, which has itself so many claims to the highest antiquity, would alone confirm this opinion, had not the absence of all those characters, which serve to distinguish the transition-slate, sufficiently established it.

I have endeavoured, in another place, to point out the abuse that has been made of the term *grauwacké;* and it might have been inferred, from the true characters which were there given of this remarkable rock, how improper it was to arrange under it any portion whatever of the clay-slate formation of this peninsula. I am willing to believe that the error is now pretty generally perceived, and acknowledged; and admitting this to be the case, what remains for us to do, but to apply the denomination either of primitive or of transition-slate, to the whole formation?

But here I am bound in candour to observe, that the use of these terms has been objected to by some geologists, because they imply a marked line of distinction which has no real existence; it being extremely difficult, without the aid of organic remains, to point out where the characters of the transition-slate first appear, and where those of the primitive slate actually terminate. In fact, it is on the absence of those characters in the primitive, which are so essential to the transition-slate, that this distinction solely rests; and as these characters are, moreover, derived from some adventitious circumstances which denote only a more advanced stage of progressive developement, (for instance, the beds of anthracite and aluminous slate, and of compact black limestone,) some embarrassment will necessarily be felt in its application. It is nevertheless true, although it rests not on any proofs afforded by organic remains, that a progressive

change may be traced from the central granite, to the remotest beds of the clay-slate on either side of it; and, that all the modifications of the latter terminate in the first appearance of calcareous matter.

Having taken the liberty of pointing out the great mistake, committed by Dr. Berger, in the use of a term which leads to so many false inductions, it is with pleasure that I avail myself of this opportunity of bestowing the praise, which is so justly due to him, for having first determined the true nature of our greenstone. This rock occurs abundantly in the slate district; and affords every where the best building, as well as road, materials. There are several varieties of it; and one of them, which I found extensively bedded in the parish of Probus, has a schistous structure. Dr. Berger is of opinion that the greenstone occupies a subordinate station in the slate formation, and the analogy of other countries gives some authority to his opinion. On the other hand, this greenstone rock is with us so important a feature, in respect to the frequency of its occurrence, and the space which it occupies, that its geognostic relation to the slate which envelopes it, would form a very interesting subject of inquiry. If, for instance, we should conceive the possibility, built upon fair induction, of this greenstone being the type of all the slate formation which accompanies it, what a different view would it not give of the nature of this slate, and of its origin?

One of the main points of inquiry to which the attention of Dr. Berger seems to have been directed,

during the very extensive tour which he made through this country, was the general underlie of the slate beds on each side of the chain of growan hills; which underlie or inclination he found on the south side of the chain to be to the S. S. East, and on the north side of it to the N. N. West. Of the accuracy of this determination, supported as it is in some degree by a few local observations of Dr. Forbes and Mr. Rogers, I confess that I feel some doubt, arising from past experience; and the fact is of too great importance to be suffered to rest on imperfect evidence: to establish it, it would be necessary to take the mean of a very considerable number of observations.

I cannot conclude this survey of the strata of Cornwall without offering some thoughts and reflections on the two great serpentine formations of St. Clere and the Lizard.

The whole area of the peninsula may be resolved into three distinct rock formations; one of which, although it occupies but a small space when compared with the two others, is nevertheless the most interesting. I allude here more particularly to the serpentine district of the Lizard: upon the borders of which at an early age, without any assistance from an instructor and with no better guide than Borlase, I first studied the phenomena of Geology. The characters of the granite and the slate formations were sufficiently distinct to impress on me a conviction of the great difference in their origin; but those of the serpentine were widely remote from either; and they

pointed out such a bold and capricious variation in the great operations of nature, as could not fail to awaken the curiosity of so youthful an observer.

The effect of these early associations is so strong, that I still feel a more than common interest in the objects which gave birth to them; and if, after an absence sufficiently long to impair my recollection of many particulars of this rock formation, I should be under the influence of some misconception, I trust that the following sketch will be found, upon the whole, to convey no unfaithful representation of the features which principally distinguish it.

Passing over the low slate hills, which form the base of a great part of its periphery, you approach the elevated platform of Gonhilly, by a rise so gradual as to be almost imperceptible. The ascent continues for some way over the serpentine rock, without any material increase of elevation; when a dead level commences, bounded by an horizon of its own; for the slate hills, which you have now left behind you, are no longer visible.

The traveller, however, if he be a geologist, will feel an interest even in this dreary country; the great simplicity of its outline, its unbroken surface, and firm consolidation, reminding him of its high pretensions to a primitive antiquity. On his arrival at the iron-bound coast which terminates this extensive platform, he will find the dull uniformity of its surface most amply compensated by the view of its internal structure; there being nothing, upon the same scale of magnitude in the mineral

kingdom, which surpasses the novelty and variety of those objects, which will now force themselves upon his attention. After the first emotions of surprize, occasioned by the sight of these cliffs, the geologist will perceive, that the singularity of their aspect is the result of the very peculiar articulation of the rock which chiefly composes them; the glazed surface of every fragment satisfactorily accounting both for its resistance to decomposition, and for its dismemberment. He will find, on a nearer examination of these cliffs, numerous veins of unctuous steatite, associated with talc of a metallic lustre, or with the most delicate fibres of asbestus; while nature, as it were in a sportive mood, has scattered through the variegated mass of serpentine her crystals of resplendent diallage. Every thing in short, which he finds here, combines to stimulate his curiosity, and to fetter his attention.

It is on the western skirts of this platform of solid rock, that the slate has been perceived in an attitude, termed by geologists unconformable, supporting the greenstone which is itself overlaid with the serpentine. It is said that some traces of transition may be occasionally detected at the points of contact between the two last-mentioned rocks, which together with a few examples which have been given of their alternation, tend to demonstrate their contemporaneous origin.

The slate, however, soon disappears beneath its unaccommodating covering; and, of the two rock masses which overlie it, the serpentine is by far

the most predominant. No circumstance is more striking, than the wide extent of table land which this rock constitutes. If it be allowable, in the present state of geological science, to conceive a process of tranquil deposition or slow precipitation of the materials of such a country from a fluid in which they were suspended, such must have been the result of it: nor do I know an instance of a formation of this high antiquity, which has remained so unaltered. Even a considerable portion is still preserved, of what may be justly regarded as its original outline.

But, although I may have indulged, for an instant, in an hypothesis which seems to account very plausibly for the exterior form of this great deposit of rock, I am led nevertheless by many circumstances to believe that the developement of its interior structure must have been influenced by the action of some disturbing causes, of the nature of which we can form no adequate conception: it being impossible to account in a satisfactory manner for the great variety of forms and of combinations of colours which here, at every step, arrest the attention of the geologist, while they baffle every attempt that he makes to reduce them to classification. It is remarkable, however, that in spite of all the diversity of characters which I have noticed, the magnesian is that which predominates.

Among the very great variety of simple and compound rocks, which nature seems here to have indulged in producing, who would expect to find

some deposites of native copper? I have examined the spot, where about eighty years ago, at a foot or two beneath the surface of the rock, many tons of this metal were discovered. Specimens of it are still preserved in cabinets, and their uncrystallized appearance has induced many persons to suppose that they were the productions of a smelting furnace. No traces, however, of fire are observable on the spot which was pointed out to me; and the same amorphous native copper is found in so many parts of the cliffs of the Lizard, and under circumstances so demonstrative of its aboriginal connexion with the rock-mass, that no doubt can be justly entertained of its natural origin.

It may excite almost an equal degree of surprize, when I mention the fact, that the steatite constitutes well characterized lodes in the serpentine; and, to fill up the list of singularities in this district, I shall avail myself of the opportunity to notice a lode, of considerable breadth, and of a very regular direction between smooth walls, which is composed of a solid mass of ferriferous carbonate of lime, (sparry ironstone). I found this lode in the cliffs which range a little to the eastward of the small cove near Landewednack, at the spot where the serpentine is so beautifully marbled with red veins, and interspersed with crystals of diallage. How singular must that process have been, which has filled the hollow space between the two walls of this fissure, with a substance so different in its nature from the rock which incloses it.

The existence of granite, or of micaceous slate, in a district so characterized by its binary association of serpentine and greenstone, would if substantiated, be a curious anomaly in the history of this formation; but the former, which has been observed only at Kynance, proves on a further examination, to be a porphyritic mass, subordinate to the serpentine; while the latter, which covers the promontory of the Lizard, is a true hornblende slate.

The very intimate connexion which subsists between the greenstone and the serpentine of this district, corresponds with observations made in other parts of the globe; and, as far as my own experience extends, this connexion is so invariable, that I recollect no instance where one of these rocks is not associated with the other. The diallage rock too, although less extensive than the greenstone, belongs nevertheless to the same natural family; and in the eastern part of this district it occurs under such varying circumstances of association with the two other rocks, as to leave no doubt of their common origin. Nor is there a reasonable doubt, as far as I can see, of the primitive nature of the whole formation.

If in the course of these observations and reflections, which have arisen from the view which I have taken of the subject, some things may have been advanced, which are too novel to produce immediate conviction, and others, which must be received as mere conjectures, it will be recollected that the sole object which I have had in view, is—*the enlargement of our field of inquiry.*

This field still abounds in the most interesting phenomena; and I cannot refrain from the observation, that while travellers glance superficially over every object, and too often from this cause, form very incorrect judgments, the indulgence which they are entitled to, cannot well be extended to native observers; from whom we have a right to expect correctness; and above all, an attention to the minutest circumstances of the case before them.

It is by this mode of proceeding that the labours of our society may be made most eminently conducive to the progress of geognosy; and the monographies of our Cornish granite, of our slate, or of our serpentine formations, if they were so treated, might constitute a work of such original merit, that its authority would be appealed to, in all controverted points, as decisive.

II.—*Some Observations on Metalliferous Veins, and their Electro-magnetic properties.*

By ROBERT W. FOX, Esq.

MEMBER OF THE SOCIETY.

(Read October, 1830.)

I have recently communicated to the Royal Society the results of some experiments showing the existence of electrical action in many of the metalliferous veins of Cornwall.

I have since repeated my experiments in Lagylass and Frongoch lead mines, situated about fourteen miles from Aberystwith, in Cardiganshire, and also in South Mold mine, near Mold, and Miller mine, near Holywell, in Flintshire.

The two former are in clay-slate; and in each of them, only one vein is worked. They yield much lead, and their vein-stones are mostly clay-slate, exactly resembling the containing rock, intermixed with more or less carbonate of lime, quartz, &c.

The veins have nearly an east and west direction,

and an underlie towards the south of about 40°. from the perpendicular. The depth of Lagylass from the surface is about sixty fathoms; but the bottom level is drained by a deep adit brought from a neighbouring valley. The vein, which is only two or three feet wide near the surface, increases to about ten feet at the bottom of the mine. Here two portions of the vein, fifteen fathoms asunder, were connected by two copper wires, through the medium of a galvanometer, which caused a vibration of five degrees in the needle, indicating positive electricity from the west.

Frongoch is about two miles from Lagylass. It is twenty fathoms deep, and is drained by machinery. The vein enlarges from three or four feet near the surface, to five or six at the bottom level, where I connected as before, two portions of the vein about ten fathoms apart, and the needle vibrated 17°.; the positive electricity in this case also coming from the west. When the eastern or negative station was afterwards connected with one twenty eight fathoms further east, the former became positive in reference to the latter, the needle vibrating about three degrees.

In my experiments in the Cornish mines I also observed that the positive electricity almost invariably proceeded from the west, in lodes having an underlie towards the south. This coincidence is interesting.

The lead vein in South Mold mine, is contained in a nearly horizontal bed of lime-stone, and produces

large quantities of ore. The direction of the vein is nearly N. W. and S. E.—its width about two feet, and its underlie about 40°. to the N. E. It has been worked to the depth of seventy fathoms; but I made my experiments in a level fifty fathoms deep, where the lead ore was very abundant; I however failed in obtaining any indication of electricity, although portions of the vein, separated by a cross course, were selected.

The temperature of a small stream of water in the fifty fathoms level, was only 51°., and the water pumped from the bottom was 52°.*

I apprehend that Miller lead mine is more productive than any other in that part of our island; it is seventy fathoms deep, and contains many veins which are found in beds of chert, and of the subjacent lime-stone. I remained on the surface with the galvanometer, whilst two wires were sent down through a shaft to the depth of fifty six fathoms, and a connexion was established between two parallel veins fifteen fathoms asunder, both dipping about 20°. from the perpendicular towards the S. W., and having a N. W. and S. E. direction, one being eighteen inches, and the other six inches wide; but I obtained no indication of electricity. A communication was then made between two portions of the same vein, yet still without any effect being produced on the needle.

* I am much indebted to my friend John Taylor, Jun., and also to Capt. A. Francis, for the facilities which they, as well as Capt. Ede, afforded my relation, J. T. Price, and myself, for descending into the mine, and making the experiments, in which they kindly assisted.

The temperature of the water pumped from the bottom was only 51°.*

In the experiments I have made, there seems to be a remarkable difference between veins in primitive rocks, and in those horizontally stratified. It would, however, be premature to draw general conclusions without further experiments, although it may be distinctly stated that I never failed to observe indications of electricity in the Cornish mines, where there were regular courses of ore, either of copper or lead, the same precaution having been taken as in the Flintshire mines: and in veins equally productive of ore, in this county, the needle was generally acted upon with considerable energy, for the quantum of effect seemed very much to depend on the quality of the vein.

In Flintshire, I apprehend, the veins are productive only in one or two of the nearly horizontal beds.

I may remark that much gunpowder is used, and many men are employed, both in South Mold and Miller mines. This is a further proof, if it were needed, that the electricity detected in lodes, does not depend on the influence of workmen, candles, blasting, friction, or percussion. The temperature, however, in both cases, was much lower than it is in the mines of Cornwall at the same depth; so that these examples show that all the above-mentioned causes are quite inadequate to produce the heat observed in the latter.

* I have to acknowledge my thanks to the resident proprietor, Thomas Harrison, for his obliging attentions, and also to Capt. Mundy and other agents of the mine, for their kind assistance in making the experiments.

I am indebted to W. J. Henwood for communicating to me some experiments which he has very recently made in Huel Friendship copper mine, in the parish of Mary Tavy, in Devonshire.

This mine is situated in clay-slate, the lode is two feet thick, its direction nearly east and west, and its underlie about 40°. from the perpendicular. He connected, by means of two copper wires, two portions of the lode forty fathoms apart, in a level one hundred and fifty fathoms deep, when the needle vibrated 15°., the positive electricity coming from the east. He then tried in like manner, two stations one hundred and twenty fathoms asunder, and found the direction of the positive current to be the same as before, but more considerable, the needle vibrating from 45°. to 50°.

He also visited Huel Betsey lead mine, in the same parish, in which the lode is a foot wide, having a N. W. and S. E. direction, and an underlie of 26°. to the S. W. He connected the wires with the ore at the two ends of the bottom level, thirty five fathoms apart, and ninety fathoms deep; but the needle was not affected, nor was it to be expected that it would be so, as the lead ore in the vein was uninterrupted by cross courses, or any other non-conducting substances, and consequently was nearly as good a conductor of electricity as the wire.

In the paper which I forwarded to the Royal Society, I have stated my views of the probable connexion between electrical currents in veins, and terrestrial magnetism; and I have also suggested

my reasons for considering the various geological theories which have been proposed, inadequate to explain the origin of veins.

The Huttonian doctrines are perhaps more plausible than the Wernerian, and the high temperature which is now generally admitted to exist under the earth's surface, has probably tended to give the former an increased degree of credibility; yet they cannot, I think, be easily reconciled with many ascertained facts: such, for instance, as the contents of lodes having a distinct reference to the rocks they traverse, not only in general, as it relates to their productiveness of ore, but still more so, as it respects their vein-stones; a greater or less proportion of which, correspond in their nature with the enclosing rocks, however frequently these may change from the occurrence of elvan courses, &c. near the junctions of other rocks.

This remark applies to all lodes, however different may be the direction of their descent into the earth: and vein-stones are, in most cases, too uniformly arranged in lodes to consist with the idea of their having been mere fragments of the adjoining rocks.

I have seen instances of lodes bounded by elvan courses on the superior side, and by killas on the inferior, and dipping at very oblique angles, yet having their vein-stones principally composed of killas exactly resembling the *inferior* rock, and containing no elvan.

It may be observed generally of vein-stones, whatever be their nature, and however infusible they may

be, that they contain the ore more or less disseminated, and often perfectly insulated, thus affording strong evidence of their being contemporaneous.

It is well known that the contents of lodes are arranged without any relation to their specific gravity, the ore being found to alternate with comparatively light substances, and the heaviest ores, such as the oxide of tin and wolfram, are commonly the uppermost.

Neither do the contents of lodes afford indications of the action of great heat: thus the oxide of tin, which becomes red by the application of fire, is very rarely if ever found in lodes, possessing this colour. Vitreous copper often occurs intermixed with the yellow sulphuret, and is sometimes found under it, although the latter so easily loses a part of its sulphur when exposed to a very moderate degree of heat. The ores of copper, lead, zinc, &c. are frequently met with in the same lodes in close contact, and even investing one another, and yet preserving their distinct characters, however great may be their tendency to combination when in fusion.

The intersections and dislocations of lodes may also be mentioned as presenting anomalies not easily explained; for instance, the extent of a shift frequently increases or lessens in depth, and occasionally becomes even reversed. Extensive dislocations of lodes sometimes occur in connection with small cross veins, and the latter generally deviate so much from a direct course, both horizontally, and in their descent, as to render it difficult to reconcile them

with the idea of slides or slips of the strata; and when lodes, having opposite inclinations from the perpendicular, are shifted in the same horizontal direction,* this effect clearly cannot be attributed to subsidence, which would tend to separate the lodes in opposite directions.

It appears to me that our stock of information relative to the geology of the mineral districts of Cornwall, might be greatly increased by the proposal of an annual premium or medal, to excite practical and well informed miners to report the prevailing facts observable in the mines under their notice; not laying, as is too often the case, an undue stress on the exceptions, rather than on the rule; and they might be encouraged to transmit illustrative specimens of the different rocks and vein-stones, with their local names. This is the more desirable, as I apprehend that in many parts of Cornwall the same terms are given to very different substances; such, for instance, as "elvan," "irestone," (iron-stone), "capel," &c. &c., and general rules are frequently adopted from local facts, of which numerous examples might be given were it necessary. If these were collected and carefully compared, they might be modified, confirmed, or discarded, and conclusions adopted, interesting to science, and useful in practice.

* An instance of this occurs at Poldice, and I apprehend it is the usual result, when lodes, having opposite dips, are shifted by cross veins.

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River & Sea Sand.

Silt, &c.

20 feet

Sea Sand

20 feet

Silt 2 feet.

Sea Sand 4 inches

Silt

10 feet.

Leaves, Nuts, &c. 6 to 12 i

Silt & decomposed vegetab matter, about 12 inches.

Tin Ground

3 to 10 feet.

Pentewan Stream-Work.

III.—*A Description of Happy-Union Tin Stream-work at Pentuan.*

By JOHN W. COLENSO, Esq.

(Read October, 1829.)

Happy-Union tin stream-work lies in a valley near the harbour of Pentuan, in the parish of St. Austell.

Several streams which rise on the southern side of the high hills of Hensburrow, (about eight miles distant from Happy-Union) flow through this valley, and there the high grounds about Polgooth mine (two miles distant) also discharge their waters.

The valley of Pentuan is a continuation of St. Austell moor, where for many ages a great quantity of tin has been gotten by streaming. It is in some parts upwards of six hundred feet in breadth, but in others not more than three hundred, and at one spot little more than one hundred. Its declination from St. Austell bridge to Pentuan is about one hundred and twenty feet; and if to the fall of the valley, we add the depth of the deposit, it will make a total of one hundred and eighty feet, or just forty five feet to a mile.

Above St. Austell bridge there is no alluvial deposit of any kind, the course of the river from its source to that place being confined and rapid; but in the four miles from St. Austell to Pentuan, the deposit gradually increases, so as at the present place of working, to attain the depth of sixty feet.

The floor or rock on which the whole of the deposit rests, is composed of blue killas, of the same kind as that of the adjoining hills and cliffs: in some places it is as hard as the hardest of that kind of stone; in others, so soft as not to support the props which it is found necessary, in driving levels, to place on it. In particular places the rock appears to be worn by friction; but in other places, especially under the tough ground, (described hereafter) there is no appearance of friction.

In describing the different parts of this deposit, I shall refer to the section, in which they are designated by different letters.

a. *The tin ground,* that is to say, the stratum in which the whole of the stream tin is found. It lies on the solid rock, and is generally from three to six feet, and sometimes even ten feet, in thickness: in width it extends across the valley, except where turned by a projecting hill or rock, when it is found to take the supposed antient course of the river, which is generally under the steepest land.

The rocks and stones which, with the pulverized matter, compose this stratum, are mostly fragments of granite similar to that of the hills near St. Austell, (exhibiting all the varieties of this rock which usually

occur near the base of our moorstone hills) all of which are considerably rounded by attrition, whereas the stones of killas and greenstone which are frequently met with, appear to have suffered but little change. Fragments of elvan, and of the hard black rock called by the miners "irestone," are also occasionally found in the mass, as well as vein-stones, and that kind of iron-ore which is called *cal.*

Most of the tin lies at the bottom of the stratum: but sometimes it is found in the higher parts, where for two or three inches in thickness the ground is in some parts quite blackened with tin, although perhaps for two or three feet below it, the ground does not repay the expence of washing it: generally speaking, however, the tin ground is best in the bottom, and although the higher part contains tin, and sometimes good pebbles of tin; yet the ground here is generally poor: indeed the smaller the mass of the tin ground, the greater is the quantity of tin contained in it.

The tin is from the size of the finest sand, to pebbles of ten pounds weight; and some rocks richly impregnated with tin weighing two hundred pounds and upwards, have occasionally been found here. The small tin, which is known by the name of grain tin, is of the best quality: the larger stones contain more waste, and sometimes also copper and mundic.

The tin ground is divided by the streamers into what they call "loose ground" and "tough ground:" the loose ground consists of sand, stones, and

pebbles; the tough ground has an additional intermixture of yellow clay, which cements the whole so firmly together as to render it difficult to be separated and washed.

The tough ground appears to be formed by the clay rising up from below it; for on removing this ground, we find oozing out of the soft killas under it the same fine yellow clay as is mixed with the tough ground: and sometimes for two or three feet below the regular surface of the soft killas, tin and other pebbles have been deposited in the place of the clay forced up. The tin ground is also of a much greater thickness where the clay appears to have been forced up; from which it may be supposed to have been lodged in its present bed immediately after the removal of the substance which before occupied its place.* We have here found a few grains and small pieces of gold; they are very scarce, and rarely so large as a pea.

In this stratum I have never met with any animal remains; but roots of trees are seen, and lately has been opened what was once an oyster bed, on the top of the tin ground, where the shells still remain fastened to some of the large stones, and the stumps of trees. The roots of the oak are in their natural position, and may be traced to their smallest fibres

* The quantity of tin ground opened at Pentuan has been seven hundred fathoms in length, averaging about twenty six fathoms in breadth, making a total of eighteen thousand and two hundred square fathoms. The average quantity of black tin gotten per square fathom has been one hundred and eighty pounds: the quantity of overburthen removed has been upwards of two hundred thousand tons.

even so deep as two feet: from the manner in which they spread, there can be no doubt but that the trees have grown and fallen on the spot where their roots are found. I understand the first appearance of decay in the oak, is its becoming stag-headed: the trunk fails next, and then the root; but at Pentuan the timber is often found quite sound, as a proof of which, I have recently applied one of the trees to make the axle of a water wheel. It appears to me likely that at this period, the rising of the sea had so far checked the current of the river as to prevent its discharging the mud and sand brought down with it; thus the roots were buried to a considerable depth, and the trees killed, before the timber underwent its natural process of decay.*

b. *A stratum of dark silt,* about twelve inches thick, apparently mixed with decomposed vegetable matter, and on the top of this is a layer of leaves of trees, hazel nuts, sticks, and moss, from six to twelve inches more. The moss appears in a perfect state, retaining almost its natural colour, and seems to have grown where it is now found. This layer of vegetable matter is about thirty feet below the level of the sea at low water, and about forty eight feet at spring tides. It is not found in particular spots only, but extends, with some interruption, across the valley.

* The specimens from the stratum of tin ground are, No 1, serge or grain tin. No. 2,—5, varieties of wood and other tins. No. 6, common pebbles of tin. No. 7,—9, specimens of the tin ground. No. 10, part of a large pebble containing mundic, broken to shew the effect produced by the action of the water on it.

c. Above the vegetable matter just described is *a stratum of sludge or silt,* of ten feet in thickness: in this there is little variation, except by its changing from a brownish to a lead colour, in particular places. The whole is sprinkled with recent shells, together with wood, hazel nuts, and sometimes the bones and horns of deer, oxen, &c. The shells, particularly the flat ones, are frequently found in rows or layers; they are often double and closed, with their opening part upwards, so as to render it likely that the fish lived and died where their remains are now found.

Shells exposed to the action of the sea are seldom found united; and it is well known that shell fish are only discovered at or near the surface of the sand or mud; this stratum, therefore, as it contains the remains of shell fish throughout, must have increased gradually, and formed layer after layer, as the fish became possessed of the surface, according to the gradual rising and influx of the sea,

The silt at Happy-Union is of so fine a texture, that it will scarcely admit air or water to pass through it; insomuch that after being once dried, it may be placed under water for a considerable time without being affected by it. It is therefore often applied by the streamers to resist water, and if formed into a basin, will hold it like earthenware. By the weight of the sand-banks on it, it is so compressed, that when taken up it is a comparatively dry mass. It is *in* and *by* this silt that animal and vegetable substances are preserved, and it is to the

greater or less admixture of these, that we must ascribe the variations of colour in this stratum.

There has been recently found imbedded in the silt, about two feet from the top, a piece of oak, that has been brought into form by the hand of man; it is about six feet long, one inch and half broad, and less than a half an inch thick; this is the greatest depth at which I have ever seen any converted substance. It appears to have floated in the sea, as at one end, which is much decayed, a small barnacle has fixed its habitation.

d. *A stratum of sea-sand,* about four inches in thickness: this is easily distinguished from the river-sand, being much finer, and having always more or less shells mixed with it. It is remarkable that the water which drains from this sand is nearly as salt as the sea, whilst all the water above and below it is fresh.

e. Above the sea-sand there are *two feet more of silt.* About the middle of this stratum there is imbedded in it a layer of stones of various sizes and forms, and of different degrees of hardness; they appear to be conglomerations of sand and silt, with sometimes wood and bones: and are found only at this level, all over the stream-work.

f. *Another stratum of sea-sand,* twenty feet in thickness, rests on the silt. In all parts of this sand there are timber trees, chiefly oaks, lying in all directions; and also the remains of animals, such as parts of the red deer; heads of oxen of a different description from any now known in Britain, the horns

of which all turn downwards; the scapula and humerus of an animal supposed to be of the ox tribe, measuring round the largest part twenty inches: these are supposed to be the bones of an ox such as is now in existence near the Cape of Good Hope. Human skulls have also been found in this sand, one of which, supposed to be either African or Asiatic, I beg to present to the society, with other animal remains, &c.* These lay near the bottom of the sand. In the upper part of this stratum, and about two hundred fathoms nearer the mouth of the harbour, the bones of a large whale were found, which shew that at the time they were conveyed here, there must have been a depth of water in the harbour, sufficient to have floated such an animal into it.

The sea at this time appears to have extended nearly a mile up the valley, as is evident from the same kind of sand being found at that distance; but further up it lessens in depth from the acclivity of the land.

After the sea had occupied the valley long enough to raise the sea-sand to twenty feet in height, the sand and wash from the hills and tin stream-works, near Hensburrow and St. Austell moors, appear to have forced the sea back to its present boundary, from which it is still retreating, and must continue to

* The specimens from this stratum of sea-sand are,—No. 1, the humerus, and No. 2, the scapula abovementioned. No. 3, jaw of a hog. No. 4, the skull abovementioned. No. 5, radius of a whale (imperfect). No. 6, humerus of a whale. Nos. 7—8, phalanges of a whale. Nos. 9—10, large bones, supposed of a whale. Nos. 11—12, stag's horns.

retreat, whilst the quantity of stones, sand, and gravel, amounting annually to many thousands of tons, is carried down by the St. Austell river to the sea.

g. *A bed of rough river-sand and gravel, here and there mixed with sea-sand and silt.* This bed is also about twenty feet in depth, and brings us to the surface. The workings being now at the mouth of the valley, and only about half a mile from the present ordinary flow of the tide; there is here more sand and less silt than further up. There have been recently found in this sand the remains of a row of wooden piles, sharpened for the purpose of driving, which appear to have been used for forming a wooden bridge for foot passengers: they crossed the valley, and were about six feet long, their tops being about twenty four feet from the present surface—just on a level with the present low water at spring tides. Had the sea level been then as now, such a bridge would have been nearly useless.

How far the valley of Pentuan once extended towards the sea is a mere matter of conjecture: but supposing it to continue at the same declivity as the ground between St. Austell and Pentuan, viz. forty five feet to a mile, it must have continued at least a mile further than it now does, to allow the trees to have grown, where we now find the roots, and still further, if we suppose the tin ground to have been lodged in its present bed either by the deluge or some other violent current. The sea now flows forty eight feet higher than the top of the tin ground.

Happy-Union stream-work was first opened in the

year 1780. In the course of a short time it was found necessary to work in both directions, that is to say, up the moor towards St. Austell, and down, towards the sea; the first was called Wheal Virgin, and the latter Happy-Union. The two works moving in opposite directions, their distance gradually increased, and they are now about a mile asunder. In Wheal Virgin the tin ground is only thirty two feet from the surface. The tin is of nearly the same quality as at Happy-Union; but both the pebbles and grains of tin are more thinly strewed, nor is the tin ground of so great an average thickness. The overburthen contains no sea-sand, but is composed of silt and river gravel, with a considerable quantity of wood, chiefly oak and willow, with the roots of the same and other trees in all places where there is any soil. Very recently I have seen on the surface of the tin ground two small pieces of oak, with artificial holes in them: and there were near them several oak stakes, sharpened and driven into the ground, and supported by large stones. Near the same spot has been found a substance resembling the ashes of charcoal. Here it is evident (to use a streamer's phrase) *the old men have been;* but whether the tin ground was then the surface; or whether they went down by the aid of machinery, (it being under the present sea level), must, until we see more of it, remain undetermined.

In closing this paper I beg to observe, that where the valley is narrowest the rock on each side is steepest; and, both on the sides and in the bottom,

harder than in other places. Where I have noticed the tin ground, in such situations, I have observed it to be less in depth, but richer in quality. The rocks and vein-stones of which the tin ground is chiefly composed, being also larger than where the valley is wider.

IV.—*Some Observations made in Cornwall, in the summer of* 1829.

By JOHN HAWKINS, Esq. F.R.S., &c.

VICE PRESIDENT OF THE SOCIETY.

(Read October, 1829.)

The indulgence with which all my former communications had been received, encouraged me at our last anniversary, to lay before this society some general views of the structure of this county, and to point out the phenomena which more particularly required investigation. The object of my present communication is to accomplish in some degree what I there recommended, and to shew both by the manner in which I conduct these enquiries, and by the attention which I bestow upon them, what we may reasonably hope to see effected by our united labours.

It is a fortunate circumstance in the life of a geologist, when he can appeal to the force and correctness of those impressions, which were made upon him at an early period of his life, by the aspect

of such a country as this is. It is still more fortunate if he can follow up a pursuit which has been commenced under such favourable auspices, in the very country which gave birth to it. But this fortunate concurrence of circumstances has been denied me, and I can now only resume a course of personal observations which was too soon interrupted, to permit me to derive any material advantage from it. Imperfect however as these early labours were, they had been conducted in the spirit of those instructions which were given me by a great master, and with the advantage of a pretty familiar acquaintance with the geology of a large portion of Europe.

In the memoir to which I have alluded, I took a comprehensive, although not a very distinct, view of the various subjects which merited investigation. My position is now changed, and those objects which at a remote distance, presented only some general features of comparison, resolve themselves, on a near approach, into distinct masses which display, when more closely examined, all the marks of their specific characters.

Directing your attention, in the first place, to the surface of this country, I shall point out to your notice, those features, which I conceive to be the most significant: for the discrimination of forms is not one of the least of the duties of a geologist, and a long habit of observing may have qualified me in some degree for this employment: although in conveying my ideas to others I feel the defective nature of our language when applied to subjects

of this kind, and must entreat your indulgence.

For the present, I shall confine myself to such observations as I have made on the slate district, and shall first notice its very great unevenness.* I have seen many countries which abounded more in bold declivities, but I recollect no one, which, with so much irregularity in its profile and outline, is so little elevated. Its smooth and undulating surface presents a never ceasing interchange of lines and angles, from which the eye finds no relief but in the contrast afforded by the few level spaces which occur in the openings of the larger vallies.

In countries of more recent formation, such as those of the lias-limestone and the old red sandstone, the summits of the hills suggest, by their horizontal level at a corresponding elevation, some idea of their former continuity; but here, although the hills are so closely packed together, and are of the same character, there is no such appearance of their original connexion.

Nor have we any examples in this country of those projecting and retiring angles, the *angles saliantes* and *rentrantes* of *Bouguer*, which are so remarkable in the vallies of some other countries, and are conceived to bear the marks of some regular law of their formation. As far therefore as the absence of this character would lead us to form any conclusion, the process to which this country owes its configuration, appears to have been of a different

* In the account of the Ordnance Survey, it is mentioned that no base of verification could possibly be measured, either in Cornwall or in Devonshire.

nature, although sufficiently consistent and homogeneous. Nor will the view which I have here taken of it be invalidated by the examination of its interior structure.

This leads me to the consideration of a subject, which since my arrival in this country, has very particularly engaged my attention. I allude to the direction and inclination of those stratified masses of rock which compose the districts of slate, both here and in Devonshire. Although my observations extend only over a small portion of these districts, yet I clearly perceive the operation of some law which must have regulated these circumstances, and I must abandon the notion of their being fortuitous. I have enjoyed, perhaps, more favourable opportunities than fall to the lot of most geologists for making these observations, having, in the course of the last summer, passed along the northern as well as the southern skirts of Dartmoor, and this too, with all the facilities afforded by an open conveyance. I found the slate beds on each side of the moor, invariably dipping in the opposite direction to that of the granite hills; for instance, their underlie on the north-eastern side of the moor was to the north-east, and on the north-western side of it to the north-west, and the same rule was observed in the underlie of the slate which bordered on the southern flanks of these granite hills, although there its direction was generally due south.* I traced the same regular

* In all these cases the magnetic meridian must be understood.

underlie of the slate as far west as Liskeard, but have some reason to doubt its extension through other parts of the county, for southward of St. Austell the slate underlies to the north, and this is its position in a very considerable district which is included between the line which I have mentioned, another line drawn from St. Austell to Grampound, another from Grampound to St. Ewe, and another from St. Ewe to Pentuan. Advancing westward from Grampound there is an interval of about two miles in the parish of Probus, where the slate is almost vertical, and this very singular position of its beds has been traced about a mile southward. At the foot of Probus hill, however, it assumes its usual degree of inclination, but at the same time very materially alters its line of bearing; the slate here underlying to the south; and this direction of its underlie continues westward as far as Truro, and southward as far as St. Michael Penkevil and Lamorran, where it underlies to the south-east. The underlie of the slate in the vale of Ladock and Tresilian, agrees in its direction with that which I observed near Tregony, but in most cases the line of bearing oscillates a few degrees only to the right and left of the general direction of the Peninsula.

To complete the view which I have here taken of the underlie of the strata which have more particularly passed under my observation, I shall avail myself of the notices which I collect from two papers inserted in the first volume of our Transactions, and these, although few in number, sufficiently

prove, that the anomaly which I have observed in the line of bearing of the strata between the valley of Probus and the district which lies directly southward of it, extends into Roseland.

I have been able to make few observations that can be depended upon, in that part of the county which lies to the west of Truro: I may be permitted, however, to mention one, which is by its extent of some importance: on the cliffs below Bosahan, on the southern side of Helford harbour, I remarked that the stratification of the slate perfectly agreed in its line of bearing with that which I observed with a telescope in the cliffs of Mawnan, which bound on the north the entrance of that harbour, and that the underlie of both is to the south.

I shall add one more remark on the subject of the underlie, in respect to the degree of its inclination, which may be said in general to vary little from an angle of 45°.

The facts which I have here collected, are the result of repeated observations which were made by me in a very central part of the county, and not without some difficulty, for the appearances of the slate beds, near the surface of the ground, are very deceptive, and it was not until I had examined the deeper sections which had been made in quarries of some extent, that I discovered how necessary it was to proceed with more caution. The cause of this lies in the very singular manner in which the slate beds terminate. It is natural to conceive that this would be in the same line as that of their underlie,

but the reverse of this is invariably the case here, and the phenomenon deserves a very particular notice. Let us suppose a case where the beds dip in an angle of 45°. to the south: at the depth of six feet or more from the surface of the ground, these beds becoming at once more taper and disjointed, gradually assume an inverted, then an inclined, position to the north, and sometimes a recumbent one, the whole figure of their recurvature describing the line of a carter's whip. This is the general case of their reaction; but frequently they are at once laid prostrate, and appear to be separated, by an even line, from the parent beds. In a few instances, at the point of separation, I have observed these terminal beds to assume a regular zig-zag direction for a few feet upwards. I have already intimated that most of my observations on the underlie of the slate were made in a central part of the county, those however, which relate to the very singular phenomenon just described, have hitherto extended not beyond the district between St. Austell and Truro.

V.—*A Description of the Stream-work at Drift Moor, near Penzance.*

By JOSEPH CARNE, Esq. F.R.S., F.G.S., M.R.I.A., &c.

TREASURER OF THE SOCIETY.

(Read October, 1830.)

Whilst the attention of this society has been largely occupied by the rocks of Cornwall, the veins which intersect them, the beds which occur between them, &c., the masses of heterogeneous materials which are found in the lower part of our vallies have perhaps had less attention than they deserve.

In describing deposits of this kind, some parts of which appear to have taken place under very different circumstances from those to which the others owe their formation, it is almost necessary to adopt a line of division which has been sanctioned by most geologists, distinguishing those parts which there is reason to consider as the result of the general deluge, from those which appear to have been caused by subsequent events, such as partial floods and inun-

dations, or the continual currents of rivers,—causes which either constantly or occasionally, are still in operation. To the former the term diluvium has been given, and to the latter,—alluvium.

The tin stream-works of Cornwall furnish many illustrations of this division, in which the later, or alluvial deposit, is clearly distinguishable from the primary, or diluvial deposit.

In the stream-work which I now present to the notice of the society, there is an instance of the deposition of a mass of stony and gravelly materials, not only subsequently to the diluvial deposit, but after that deposit had undergone the process of streaming for tin.

Drift moor forms a part of the valley which opens at Newlyn, and ascends westward and north-westward by Trereife, Barius Bridge, Nancothan, and Drift. Here the widest part terminates, and two smaller vallies open from it:—one towards the north called Tregavara Bottom;—the other towards the north-west called Tregonhoe Bottom. The river which flows through Tregavara Bottom rises near Lanyon in Madron, and runs southward under the new bridge on the St. Just road. The north-western stream rises near Botrea in Sancreed, and takes its course by Trerice and Tregonhoe.

The whole of this valley from Trereife upwards, bears the marks of having been at different periods, extensively streamed. In Tregavara Bottom, the heaps in the valley, as well as the barrows on the declivity of the hill called Tregavara Downs,

point out that spot as one which, in past times, has yielded a considerable quantity of tin, from lodes as well as from streams. At present, however, scarcely any thing is done north of Drift moor, either in streaming or in mining.

The commencement of Drift moor stream-work on the north, is just at the point of union of the two before-mentioned rivers, where the two small valleys open into the large one. This point appears to have been its richest part, for although the tin ground continued down the valley, and has been wrought for perhaps half a mile in length, it was not (as far as can now be ascertained) either so extensive or so rich as at the northern point.

It is scarcely to be doubted that this valley was explored in search of tin at a very remote period. It will appear, from facts which will presently be adduced, to have been explored at a period earlier than the use of any kind of machinery in mining; and from other circumstances, it seems to have been again explored at a period much nearer to the present time, although beyond the records of the history of such events. The present workmen commenced their operations about twenty years ago, beginning their work further down the valley, and proceeding upwards. They continued several years with various success, sometimes finding a rich bed of tin ore which had escaped the notice of the former workmen, but generally employed in turning over the heaps from which most of the tin had been already extracted.

At length they came to a spot in which were

several of the protuberances known by the name of *shambles*, by which the ancient workmen threw up the ore from cast to cast, until it reached the top. As they knew this was the most ancient mode of working, they fondly indulged the belief that no operations had taken place since the introduction of any kind of machinery; and expected to find a body of unexplored and rich tin ground, especially as they had just before discovered what they believed to be the commencement of a rich bed of tin ore; but to their great astonishment, instead of realizing the prize which their sanguine hopes had anticipated, they burst upon an ancient water engine, buried in the alluvial soil; a discovery which entirely blasted their expectations.

This engine was a machine formerly well known in Cornwall under the name of a *rag and chain pump*, a name originally given to it because it was composed of bunches of rags, fastened at certain distances to a chain, which turned on two small wheels, one at the bottom, the other at the top of the shaft,—the latter connected with a large water wheel: the water of the mine, absorbed by the rags, was thus carried to the surface. Small buckets were afterwards substituted for the rags, but the machine retained its original name: the principle is nearly the same as that of the chain pump still in use in ships of war. Whoever has been in the gardens at Versailles, has probably seen an engine as nearly as possible on this principle, although far different in point of elegance. The wheel of the engine at Drift moor was twelve feet

in diameter, and eight inches wide: the top of it was six feet below the surface of the mass of gravel, &c.: the only iron in the whole machine consisted of the milliars of the wheel,—two bends on the axle,—and the chain of the pump: not a single iron nail or bolt was found in any part of it: the different parts of the wheel were fastened together by wooden pins. The pump appears to have been made from one piece of timber which had been sawn in two, lengthways, and each piece had been scooped out, so that when united they formed a tube of seven inches in diameter: these parts were also united by wooden fastenings, without any iron, and so were the parts of a wooden shaft, twenty four feet deep, in which the pump stood, which, when discovered, had sustained little injury, although it was filled with stones and gravel. The small buckets fastened to the chain were also of wood. All these circumstances prove this machine to be at least from one to two centuries old: indeed it has been scarcely used in mines since the early part of the last century. Another circumstance in favor of its antiquity is the absence of all tradition of the occurrence of so singular an event as the overwhelming of a water engine by a mass of stones and gravel.

Amongst several articles which have from time to time been found in this stream, I have met with three copper coins, which were found by the present streamers in the rubbish left by the former workmen; but on one only, a Portugal coin, is any part of the date or inscription legible, the figures 169 are very

distinct: the fourth figure is wanting; but no stress whatever can be laid on this as a guide to the period when the water engine was probably erected, as it is very possible that the stream has been partially explored at different times subsequent to that period.

From the engine let us now turn to the recent or alluvial deposit, which must have been lodged there after the erection of the engine: it consists principally of stones and gravel, with a small mixture of earthy matter: the whole probably formed a part of the original diluvial detritus in the higher parts of the valley, and was forced downwards by a great overflow of the river: this appears further evident from the naked masses of granite which occupy the bed of the river above, from the crevices of which the gravelly matter seems to have been swept away. It rests on the heaps which had been previously explored by the streamers. Had not the engine been discovered, it would perhaps not have been suspected that the recent deposit was different from the other, as the latter, having been previously turned over, had lost the particular marks by which it might have otherwise been distinguished. The greatest depth at which the alluvial mass is now perceptible is fifteen feet; it must however, have been much deeper where the shaft stood, but from this spot it has been wholly removed by the workmen. The line of division, although irregular, is perfectly distinct, the oldest being of a much darker colour than the more recent: it contains a few scattered tin stones, not worth the trouble of searching for.

The deposition of this recent body must have been in some measure gradual: had such an overwhelming mass come down at once, it must have broken the fragile machine to atoms: on the contrary, the engine was found in the situation in which it had previously stood: almost every part in its place, and very little disordered,—indeed the only injury which it appeared to have suffered, was the fracture of some of the buckets of the wheel: the pump chain was also wanting, but the greatest part of it was afterwards found in the shaft. If however, the engine had not been suddenly inundated, it would have been removed by the workmen: it is therefore probable that the excavation in which the engine stood was suddenly filled with water, but that the stony and gravelly materials were gradually brought down, either during one long-continued flood, or by the force of successive floods; the former is the most likely, as there are no marks of stratification which intimate different periods of deposition.

Some particulars relative to the most ancient part, or the diluvial deposit, now merit our notice. The excavation made by the workmen has an irregular circular form, diminishing in space as it descends. Its depth from the surface is about forty feet, and the bottom is clay, or *fast ground,* below which it is not expected to find tin. The workmen found that the ground had been previously explored to the depth of thirty six feet; they have therefore gone only four feet deeper than their predecessors. I find it

difficult to give an intelligible description of the singular position of the tin, and the clay on which it was found. Form an idea of a piece of level ground whose surface is clay, on which is deposited a bed of tin ore: suppose the ground underneath to give way, no matter how, just in the centre of this spot, and a cavity to be made at the surface, somewhat like a funnel, or rather a basin: the clay and the tin would then probably be found reclining on each side of this basin. This is nearly the position in which they are actually found in Drift moor. The present excavation has a wall of clay on every part, except towards the north, (the point at which the alluvial deposit came in). This wall slopes like the sides of a basin from the surface to the bottom. The tin in those parts where it has not been taken away by the ancient workmen, has been invariably found on this sloping wall or bed of clay: it was found as high as within a few feet of the surface, and in its course downwards it declined according to the declination of the clay. The middle of the basin was filled with detritus containing scarcely any tin. The clay is not every where of the same thickness, nor has it the same declination. Westward it varies from seven to twelve feet, and declines at an angle of about 52°. Eastward it is thicker, being twelve feet at the surface, and declines at an angle of about 38°. Southward it is much slighter. On the outside of the clay walls, the stony and gravelly matter is found as deep as within the basin. At the depth of forty

feet, as has been already observed, the bottom is all clay, and there of course is the termination of the stream-work in depth. It is to be especially noticed that the bed of tin resting on the clay, is no thicker at the bottom of the basin than on the sides, being about four feet of good tin ground, and a few feet of what is inferior.

From the whole of these circumstances, we shall be almost led to the conclusion that some parts of this valley (for the clay is found in the same position in other parts of it) have sunk since the period when the tin was deposited on the clay, and what gives stronger probability to this supposition, is the fact that the stones which abound in the clay are found not on their flat part, but on their edge.

No animal or vegetable remains have been discovered in this valley by the present workmen; nor was this to be expected, as their operations have not been carried on in undisturbed alluvial beds, but have been confined to a spot which had been previously and perhaps successively explored.

In conclusion I may perhaps be allowed to remark that the stream-works of Cornwall appear to me to be most decidedly opposed to the doctrine that "all "the changes which have taken place on the earth's "surface have arisen from causes which are still "in operation." They, on the contrary, furnish the strongest proof of one sweeping inundation, the effects produced by which have never been repeated by any subsequent flood. In many of these deposits there are several alluvial beds resting on the diluvial

detritus: in Pentuan there are even beds of marine origin; but where is the tin? only in the very lowest part of the primary deposit, and resting immediately on the solid strata of the earth. None of the more recent beds have such an accompaniment: no secondary deposit has ever been found, the lowest part of which is a bed of tin ore.

Whilst, therefore, we have evidence before us of a succession of floods, we have evidence equally strong of a great and general inundation, which must have extended to the highest points where tin existed, as well as to the valleys: and from the almost total absence of tin in the mass which is now found to rest on the primary diluvium, we may infer with an able writer, that such a deluge has never occurred since.

I am well aware that abundant proofs of this might easily be adduced from other sources; but those which I have now alluded to, appear to arise naturally out of the subject of the present communication.

VI.—*On some of the Deposits of Stream Tin-Ore in Cornwall, with remarks on the Theory of that Formation.*

By Mr. W. J. HENWOOD, F.G.S.,

MEMBER OF THE SOCIETY.

(Read in 1828 and 1829.)

I beg to offer to the notice of the society the result of some observations on certain stream-works, which I have examined, with a few considerations on the generally received theory of their formation.

Carnon stream is situated very near the extremity of a navigable branch of the Fal, which receives several rivulets arising in the hills of Stythians and Gwennap. Some of the hills of Stythians are of granite, others of clay-slate, and in a few of them there is a junction of both these rocks. But few mines have yet been worked there, and but little ore of any description has been hitherto found in them. In various parts of the vale between Carnon and Stythians search has been made for stream tin-ore, but with little success.

The composition of the Gwennap-hills is similar to that of those in Stythians, and probably no spot in the world, of equal extent, has afforded a larger quantity of metalliferous minerals. Here are the Consolidated and United mines, Poldice, Huel Unity, Huel Gorland, Huel Damsel, and many other well known tin and copper mines, all of which are from three to five miles from Carnon. At the distance of two miles are Bal-dhu and Huel Hope mines, which have afforded blende in abundance; and galena has been found in the immediate vicinity of the stream-work. The hills, which bound the Gwennap vale, are precipitous, but not craggy; and the declivity from the mines to Carnon is about 3°. from the horizon. At Carnon the vale is not less than three hundred yards in breadth, the hills on the south being rather steep, whilst on the north their declivity is very gradual. A section of the deposit in this place presents the following beds,—beginning from the top.

*a.**	Sand and mud; the river wash; in two beds.	3 feet.
2.	Silt and shells....three successive beds....	10 inches.
3.	Sand and shells (a stream of fresh water percolates this bed).....	2 feet.
4.	Silt.....three beds.....	12 feet.
5.	Sand and shells.....	3 to 4 feet.
6.	Silt mixed with shells in large quantities.....	12 feet.
7.	Silt in some places containing stones....	18 to 22 feet.

* The letters prefixed to the several beds denote their being, in my opinion, contemporaneous with, or continuations of, the beds in the other stream-works, to which the same letters are prefixed. The figures denote the beds whose identity is probable, but not so evident.

b. Wood, moss, leaves, nuts, &c., all of a dark colour, much resembling what has been charred; a few oyster shells; animal remains, those of the deer being most abundant, and some human sculls..... 1 ft. 6 in.

Towards the sea the bed *b* entirely disappears; giving place to 7, which reposes on

c. The *tin-ground*, which consists of rounded masses of tin-ore, in some cases unmixed with any other substance, in others in a matrix of quartz, and quartz and schorl *(caple)* with rounded stones of slate, granite and quartz, varying in thickness from a few inches to twelve feet..... avrg. 4 ft.

Below this is the *shelf*, which is dirty white and pale blue clay-slate, traversed by veins of clay and soft quartz, containing iron pyrites and blende. When the *shelf* is white and soft, the *tin-ground* is deeper (thicker), and of better quality than elsewhere; but that part of it, which is nearest the *shelf*, is not usually the richest; and that found in the depressions, or pits in the *shelf*, (called by the streamers *whirls)* is frequently the poorest: these pits are not more numerous in soft than in hard *shelf*. Neither copper nor lead ores have been found in the *tin-ground*, although small pieces of blende sometimes occur, and minute and perfect cubes of iron pyrites are frequent. The upper surface of the *tin-ground* is perfectly smooth, and its gradual declination towards the sea conforms to that of the vale. In several places *a bed of sand or gravel intervenes between the higher and lower portions of the tin-ground*, at about four feet above the *shelf;* the por-

tion which rests on the sand is usually loose, poor, and of large stones; whilst beneath it, the *tin-ground* is mostly rich, and occasionally cemented by ferruginous matter. I have never seen or heard of organic remains in the *tin-ground*, either beneath or above the sand. In one spot the *tin-ground* was found to have been previously worked, but no tradition of the period has descended to us; and although a mound would have been required to prevent the influx of the tide, yet no traces of such an erection have ever been observed; the only discovery in these antient workings being a shovel made of wood, and a pick of horn. The tin-ore was found in the largest quantity at the two points, where the Stythians vale and a glen called Smelting-house vale, open into the Carnon vale; although very little has been discovered in either of the two former previous to such union. The pebbles of tin-ore are much larger towards the sea, than further up the vale. In one spot a patch of slate of some hundred feet area, which appeared to be unconnected with the *shelf*, reposed on the *tin-ground*.

All the following are situated on a plain at the foot of the Hengsborough chain, and on the north-eastern side thereof, and occur in a vale which descends south-east from Roche.

Merry-meeting stream, in the Fore-moor, parish of Roche, in section, exhibits

a. Mud, apparently mixed with decaying vegetables ..... 2 to 3 ft.
1. Gravel, granitic, resembling the adjacent strata 2 feet,

2.	Silt, mica disseminated in decayed vegetable matter	4 to 5 ft.
b.	Granitic stones, gravel, and sand, indiscriminately mixed with silt,—nuts frequently occur in this stratum	4 feet.
3.	Vegetable matter, provincially denominated *fen*, seemingly resembling the vegetable now growing on the surface, mixed with moss, grass, and sand. The vegetable substances having the charred appearance before mentioned	1 foot.
4.	Silt, apparently containing vegetable remains	1 foot.
5.	Vegetable remains (like No. 3,) having the charred appearance	1 to 3 ft.
6.	Vegetable matter resembling the preceding, but that it passes into silt	8 to 10 in.
c.	*Tin-ground*,* the tin-ore being but little rounded, and in the state of sand and small pebbles. It is mixed with quartz, granite, and schorl-rock. Where the substratum is softest the tin-ore is of the best quality, and is found in the largest quantity	4 to 30 ft.

The *shelf* is disintegrated (or rather friable) granite, which, to a depth of twenty feet, or more, is sometimes impregnated with tin-ore.

In some parts of this stream-work the *tin-ground* is horizontally divided by the interposition of a bed of friable granite; in the spots which I have seen, it seems a mere projection of the stratum by which the tin-bed is laterally bounded, and in no instance which I observed, did it extend more than ten feet from the main body of the rock.

Rock, Bell, or Mulinnis moor, in St. Austle, presents on section similar phenomena in every respect, but that the tin-ore is more abundant than at Merry-meeting.

* Rocks of quartz of enormous size are of frequent occurrence; some of them as much as fifteen feet square.

The tin-bed of *Grove* stream-work, at St. Austle, at one hundred and fifty, or two hundred yards, from its lateral termination, is horizontally divided for about thirty feet in breadth, by a bed of friable granite, which is almost identical in composition with the *lower shelf*, and is about nine feet in thickness. This bed, technically denominated a *false shelf*, was not, when I saw it, apparently connected with any other body of granite. The tin-ore beneath it is principally in the state of small pebbles; it is about twenty feet in thickness, and in one spot I observed it much mixed with granitic clay.

At *Levrean*, in St. Austle, the breadth of the tin-bed is about forty feet, and its thickness about seven feet. The granite on each side projects in such a manner, as to divide that deposit horizontally for a very large space, into nearly equal parts. At the out crop of the *upper* portion of the tin-bed, it is covered by but little alluvium; but of the *lower* part the lateral termination to the north has not been discovered, although many excavations have been made in that direction, some of which have been extended several fathoms.

Water-gate stream-work, in St. Austle, affords a section of

a.	Mud mixed with granitic sand and gravel....	5 feet.
1.	Fine granitic sand.....	2 or 3 in.
2.	Silt apparently containing decayed vegetables	2 ft. 6 in.
3.	Fine granitic sand (as No. 1,).....	2 or 3 in.
4.	Silt similar in appearance to No. 2.....	3 feet.
b.	Silt, sand, gravel, and large stones, indiscriminately mixed.....	3 feet.

b.	Vegetable matter (*fen,*) passing into Silt in the lower part; similar to 5 and 6 in Merry-meeting	5 to 6 ft.
c.	The *tin-ground,** the ore being in the state of sand and pebbles, the latter larger than at Merry-meeting	2 to 20 ft.

The *shelf* is of friable granite, harder than that in those before mentioned. It is observed that where the *shelf* is most elevated, there is a depression of the *fen*-bed; both causes thus simultaneously operating to diminish the thickness of the tin-bed.

A section of *Pendelow* stream-work, in St. Austle, affords

a.	Granitic sand and gravel	12 feet.
1.	Silt apparently of vegetable matter	1 foot.
2.	Granitic sand	4 feet.
3.	Vegetable remains, resembling No. 5, of the preceding sections; but being less compact it is penetrated by the sand	2 feet.
b.	Silt, sand, and gravel, indiscriminately mixed	2 feet.
5.	Vegetable matter (*fen,*) in every respect similar to bed No. 5, of the preceding sections	4 feet.
c.	The *tin-ground,* but the tin-ore is not abundant; the upper part for two feet in depth, contains much less than that which is beneath it	5 feet.

The *shelf* is granite in a state of disintegration, but it is less friable than that of any of those before mentioned. This is in the *centre of the vale.*

I notice the various stream-works in the order in which they occur in the vale; Merry-meeting being nearest to the head of the vale, and Pendelow nearest to its lower extremity, from which it is, however,

* A stone of felspar and schorl was met with at a place where the tin-bed was about six feet thick, and at the distance of three feet, another: the two on being placed in contact *fitted exactly*, the prominent parts of one into the vacuities of the other. Both occurred in the *tin-ground.*

very distant. They are all in the same vale, and, undoubtedly, on the continuation of the same bed of tin-ore; but a small vale opens into it from the north, in which a tin-bed has been extensively worked in several streams. In this occurs ***Broad-water*** stream-work, Luxullion, of which a section presents

a.	Granitic sand	6 to 7 ft.
b.	Mud, apparently of vegetable origin; mixed with much granitic sand and gravel.....	4 to 5 ft.
5.	Vegetable remains, resembling No. 5, of the preceding sections.....	4 to 5 ft.
c.	The *tin-ground;* the tin-ore being in the state of small pebbles, some of which are but little rounded. As at *Grove* and *Merry-meeting*, the tin-bed is sometimes divided by the intervention of a bed of friable granite; and as at the latter, numerous large blocks of quartz repose on it; beneath these the occurrence of tin-ore is not abundant.....	7 feet.

The *shelf* is of soft granite.

At a spot in Luxullion, called Savarth, situated on a small eminence, and immediately adjacent to Broad-water on the north, tin-ore is in a few spots found in the vegetable mould; and abundantly in friable granite, at less than one foot in depth. It resembles that of Broad-water, and is equally rounded. At Polskeys, a similar spot, bounded on the north by Broad-water, and on the south by Merry-meeting, and the other streams before mentioned, a bed of stream tin-ore, about twelve feet in thickness, enters the friable granite, and is seen for some distance beneath it.

At *Treloy*, in St. Columb-minor, in a bed of tin-ore of small thickness, covered by about eight or ten feet of silt, vegetable matter, sand and vegetable mould, various antiquities have been discovered; viz. *celts*, corresponding in shape with some figured by Borlase.* They, as well as some *brooches*, coins and small rings, all discovered *in* the tin-bed, appear to be made of brass. A slight crystalline incrustation was perceptible on one or two of the coins, similar to that observed by Mr. Carne,† and Dr. John Davy.‡ I suspect the coins to have been Roman. The rings, perhaps, were the *magic rings* of the Druids,§ and the *brooches* seemed to be such as we are told they used.|| Traces of previous operations were discernible in several parts of this tin-bed.

I feel much diffidence in offering remarks on the generally received opinion of the stream-tin formation; and I should probably have entirely suppressed this part of my communication, had it not been for the kind encouragement of several distinguished geologists.

1. The occurrence of tin-ore near the surface in veins, which at greater depths afford the ores of other metals, to the entire exclusion of those of tin, is by no means unfrequent. But the quality of the tin-ore found in the stream-works is very considerably superior to that of the produce of veins at small depths.

2. The ores of copper and zinc occur in much

* Antiquities of Cornwall, Plate XX. Fig. 8.

† Cornwall Geo. Trans. vol. III. p. 143. ‡ Phil. Trans. 1826.

§ Borlase, Antiquities, p. 147. || Ibid, p. 121.

larger quantities than those of tin, in the mines near Carnon; lead-ore is also found in the vicinity, and small pieces of gold have been frequently met with among the tin-ore of Carnon. If the tin-ore were originally formed in the veins, and brought from thence by aqueous action, can any sufficient reason be given for the absence of copper, lead, and zinc ores from the tin-bed of Carnon? It may be replied that they have been decomposed, and have passed off in solution. But a few pieces of blende have been found among the tin-ore; and the principle of galvanic protection, announced by the late Sir Humphry Davy, (that when different metals are submitted to oxidizing influence, that which has the smallest affinity for oxygen is protected from its action, at the expense of the one most readily combining with that element,) suggests that if the ores of copper had ever existed in Carnon, decomposition would naturally have taken place first on the zinc ores, and that the copper would have remained till after their disappearance. Moreover, whence comes the gold so frequently found in stream-works? None has ever been found in the mines of Cornwall.

3. Some of the tin-beds are horizontally divided by beds of friable granite (*false shelf*). If we imagine the portion *above* the granite to be the diluvium, we are at a loss when attempting to attribute the lower part to the same cause; and if we consider the *lower*, the diluvium, what can we say of the upper?

4. If the tin-ore found in stream-works were torn from veins in the neighbourhood by diluvial

action, an immensely larger mass of the contiguous strata must have been simultaneously removed; but of such substances, the quantities occurring in stream-works, bear but a small proportion to the masses of the tin-beds.

5. Of the streams which fall into Carnon, none rise more than eight miles therefrom, and most of the tin-mines in the vales through which they flow, are not more than four miles distant. However favourable to attrition the circumstances attending the removal of tin-ore by diluvial action for so small a distance, I hold it difficult to imagine the possibility of their being rounded by that means. Moreover, we may suppose that the violence of a torrent, which would fracture and transport so great a mass of solid rock, would not be the most likely to induce a rounded form, on the fragments it removed; but would probably rather shatter them into smaller pieces, still of angular and irregular forms.

6. It is also inconsistent with the idea of diluvial action, that the pits in the shelf, already described, are not more numerous nor larger where it is soft, than where its materials are of greater hardness.

7. The substances falling from suspension in a liquid, must either subside in the order of their specific gravities, or not. That the former does not obtain appears from the contents of the *pits* being frequently poor and light; and that the reverse does not, to the full take place, is evident, as organic remains do not occur *in* the lower portions of the tin-beds.

8. On the tin-ground in Carnon (and also in the upper portions of some other beds in which the tin-ore is not abundant) occurs a mixture of granitic, slaty, and quartzose stones and pebbles, with trees, their branches and leaves, nuts, shells, human sculls, and the remains of deer. So heterogeneous a mixture, I imagine, cannot have been caused by any flood of which we have had the opportunity of witnessing the operations; and I am, therefore, disposed to consider these the true diluvium.

9. Unfractured crystals of tin-ore and quartz are not unfrequent in tin-beds, among rounded masses of the same substances. If the rounded form be caused by attrition, to what can we attribute the preservation of the angles of the perfect crystals?

10. The *debris* brought down by the torrents from the hills, would at first be deposited in the vales, and probably *on* the alluvium they then contained. As the inundation advanced, so in proportion would it subside further and further up the hills' sides; until at length the total submersion of the land would terminate these hill-torrents. But before their entire cessation, vast currents, sweeping over immense surfaces, and of which eminent geologists have traced the directions, would have obtained. Their powers of abrasion were probably much inferior to the torrents, and their operations would, I imagine, have been confined to the summits and elevated parts of hills, and the vales parallel to the direction of their currents; saving only the effect which the action of eddies would have pro-

duced near the gorges of vales having a direction transverse to the course of the stream. These would, doubtless, have materially modified the position and form of the diluvium of the torrents; not only on elevated spots, but in the parallel vales and other places, to which I have already alluded, and may satisfactorily account for the general absence of stream tin-ore on the higher parts of the hills: for great stress ought not, perhaps, to be placed on its occurrence in two or three instances. But as these remarks are not applicable to large portions of transverse vales, and as the subsidence of the diluvial waters was gradual, and consequently did not induce violent currents on the hills' sides, I do not see any theoretical deduction, which leads to an explanation of the general absence of stream tin in considerable quantities on the declivities of many of our hills.*

The foregoing facts and arguments lead me to the conclusion, that of our *large* deposits of stream tin-ore, the lower portions are of ante-diluvial formation; whilst the higher parts of them, *with the whole of some* of smaller extent, and the mixture of trees, nuts, leaves, sand, gravel, pebbles, &c., are the true diluvium.

I forbear to offer many reasons of minor weight which are, perhaps, already sufficiently obvious, as I have now to apologise for the prolixity of these excursive remarks.

* The immensely larger quantities of stream tin-ore found in vales opening to the sea on the south and south-east, than in those of which the lower terminations are on the north and north-west, must be obvious to the most superficial observer.

VII.—*On the State of our Tin-Mines, at different periods, until the commencement of the Eighteenth Century.*

By JOHN HAWKINS, Esq. F.R.S., &c.

VICE-PRESIDENT OF THE SOCIETY.

(Read October, 1830.)

In a preceding communication, which has been read before this society, and has since appeared in their transactions, I have traced the uninterrupted working of our tin-mines during the decline and fall of the Roman Empire, and throughout the whole period of the middle ages. The evidence of this very important historical fact is principally founded on the uses of tin, and on the demand for it, combined with the remarkable circumstance, that Cornwall, during the above period, was the only country which produced that metal.

Having demonstrated in this way, the working of our tin-mines, for so long a series of ages, I shall now endeavour to point out the fluctuations, which have occurred in their prosperity.

I shall commence the enquiry by observing, that in the absence of almost all periodical records of the produce of these mines, we must be content with drawing our inferences, chiefly from such historical notices as have any direct, or indirect, bearing on the question before us; but without pushing these inferences any farther than the premises would warrant, or in other words, indulging in mere conjecture.

It is evident, I think, that the demand for tin, while it kept pace with the progressive civilization of Europe, must have varied with the political circumstances of the times. A state of war, for instance, between England and France, or the neighbouring countries, would occasion a temporary interruption of this commerce, and check the prosperity of the mines; while a long continuance of peace, and commercial treaties, such as those which Henry the Third concluded with the island of Gothland, and Edward the First with the Hanseatic towns, must have greatly promoted it.

An important change too, must have taken place in the state of our mines, when Cornwall ceased to form a portion of the Royal domains, and became vested in the eldest son of the monarch. A still greater, and a more favourable change, when a code of mining laws was enacted, and a court established for the local decision of all mining causes. Lastly, it is fair to conclude, that the right of preemption, which was occasionally assumed and abused by the Duke of Cornwall, must have had some influence on our mining system.

The result of the preceding inquiries has shewn, that the use of bells constituted the chief demand for tin, during the middle ages; and that a great revolution in this trade must have taken place in the 13th century, when a new demand for it was created by the employment of cannon. After that period, the very rapid advance of the civilization of Europe, must unquestionably have multiplied the uses of this metal to an astonishing degree, and given a new *impetus* to mining speculation. It is to this *impetus*, occasioned by the increased civilization of Europe, that we must attribute most of the improvements which have taken place in the art of mining, and in the processes of smelting. We owe many of these to Germans, and a few of them to our native ingenuity, particularly the most important one of all—the employment of steam.

Having thus taken a general view of the subject which is proposed for this inquiry, I shall proceed to examine the sources, from which a more positive knowledge of the history of our tin-mines may be derived.

To begin with the period of the Romans. However regardless they appear to have been of the interests of commerce, it is certain that they considered mines in a financial point of view, and that in every country which they had subdued, they encouraged the active working of them. We read of a Comes Metallorum, and of a College of Miners; and the traces of a very enlightened system of opening and conducting them, may be perceived in all

those ancient mines, which are decidedly of this epoch. There are numerous examples of Roman pigs of lead with inscriptions on them, which have been found in Derbyshire, in Flintshire, and in other parts of the island, where lead-mines have existed; which shew the result of this policy; and there is reason to think that they had worked some mines of English iron.

It is, therefore, not probable that after the conquest of the southern part of this island, the Romans should not have directed their early attention to a province, which having, for so many ages, supplied all the world with tin, was capable of contributing so largely to their fiscal revenue. Nor is the fact, which we are thus induced to admit on such indirect evidence, without some better support; for there are well authenticated instances of the discovery of Roman coins in our old tin-mines and stream-works.

I suspect that most of those very ancient works of fortification, which are scattered over the southern parts of this county, derive their origin from the Romans: and both the position of these works, in regard to each other, and their number, lead me to suppose that they must have been constructed with a view to secure the revenue, which they derived from these valuable mines and stream-works. I refer to the thirty-first sheet of the Ordnance map of England for the facts upon which I found this conjecture; and the connexion between the tin-mines and stream-works, and these fortifications, seems to be confirmed by the discovery, made a few years ago,

at the distance of about a furlong from one of them called Castle Zen, or Zends, in the parish of Veryan, of a block of tin of a singular form, which has on it an inscription in Roman letters.

The successors of the Romans were too far behind them in the scale of civilization, to uphold their system of civil administration; and the arts of mining, as well as of agriculture, must have declined, until the general introduction of christianity, and the active intercourse which took place with the capital of the christian world, had established a better order of things. Such was the civil condition of the Saxons, when Athelstan extended their conquests over the south-western parts of the island; but we have no evidence of their attention to mining affairs: nor, while the Danes continued to make their predatory descents, could the miners have held any intercourse with foreign merchants, or have found means to dispose of their produce. But the Norman conquerors, by uniting all the parts of the island under one government, restored this commercial intercourse; and it was then, if not before, that the Jews settled here, and eventually became the monopolizers of this lucrative trade.

It is not easy for us to decide, whether such a state of things was prejudicial or advantageous to the tin-mines; although the immense riches which Richard, King of the Romans, is said to have derived from them, would lead us to suppose that they were very flourishing at that period. The Jews indeed were stigmatized as usurers, and their

banishment under Edward the First, anno 1290, was in consequence of the religious feelings of the people, a measure of great popularity; but it proved, nevertheless, very injurious to our mining interests; for the Jews appear to have been the smelters of our tin, as well as its exporters; and the complaints which were made by the principal lords of the lands which abounded in tin, together with the loss which was sustained by the Earl in his revenues, after their departure, when, as Carew says, the mines were left unwrought, are said to have induced Edmund, Earl of Cornwall,* son of Richard, King of the Romans, to grant the tinners a charter, with sundry privileges, among which was that of a separate jurisdiction. In Carew's time this charter was no longer in existence: "howbeit," says he, "I have learned, that "in former time, the tinners obtained a charter from "King John, and afterwards another from King "Edward the First, which were again expounded, "confirmed and enlarged by Parliament, in the "fiftieth year of Edward the Third, and lastly "strengthened by Henry the Seventh, who granted "that no new laws affecting the tinners, should be "enacted by the Duke and his council, without the "consent of twenty-four persons, called stannators, "chosen six out of each of the four stannaries, or "mining districts, into which the county of Corn-"wall was divided;" and in this manner the tinners successively obtained all those privileges and immu-

* Who succeded his father in the year 1272. The Charter was granted in 1305. Vide Tonkin's MSS.

nities, which have conduced so much to the stability of the tin-mines.

There can be no doubt that the intercourse, which Edward the First (1303) promoted and encouraged with the Hansetowns, must have given a new life, as well as a new direction, to the commerce of tin; that metal being one of the articles of national produce, which the merchants of those towns were allowed to export from England. It has also been proved in another place, that Bruges became the great *entrepot* of this commerce, and that it long continued to be so, until an intercourse was opened by sea with the great commercial republics of Italy.

But I must recur to some other political circumstances, which have had an influence in promoting or retarding the mining prosperity of this country; and one of the most important of these is the royalty of mines.

Although, in modern times, the Sovereigns of Europe have assumed an exclusive right to all the mines, which are discovered in their dominions; yet it is certain that this right was never exercised by the Romans. By the Roman law, the mines belonged to the owner of the soil in which they were found, and in uncultivated districts every one was at liberty to open them on his own account. A tax only on their produce was payable to the state. The right of the Sovereign to all metals, or what is called the royalty of the mines, appears to have originated in the constitutional form of the empire of the Franks, although it was not generally exercised until a much

later period. In process of time, it was gradually assumed or usurped by all the feudatory Princes of the German Empire, as they succeeded in establishing their independence; and it has since then been either formally or tacitly conceded to them.

A right so distinctive of feudal sovereignty, could not fail to become, sooner or later, the acknowledged law of Europe. It was first established in this island by its Norman conquerors, whose successors appear to have exercised it under some limitations, which were dictated by their policy, and well calculated to mitigate its severity. With regard, however, to the tin-mines of Cornwall, it was soon found to be both useless and impolitic to exercise this prerogative, and it was tacitly permitted to lapse to those who by the law of nature were best entitled to it.

The right of preemption, nevertheless, which is founded on the royalty of the mines, was reserved by the Duke of Cornwall as a part of his prerogative, and has never been formally abandoned. Its exercise has been often oppressive, of which Carew mentions an instance that happened in the reigns of Edward the Sixth, and Queen Mary; but the particulars are set forth more at length in Beare's MSS. and nearly in the following words. Gilbert Brookhause obtained, for a great sum of money, by a grant of Edward the Sixth, a lease of the Prince's right of preemption of the tin in Cornwall and Devon, for a certain term of years. This person associated with him Thomas Raydon, and soon appointing both sale and price, monopolized the whole trade. The

tinners deprived of the advantage of ready money, and oppressed by the lowness of the price, obtained redress in the first year of Queen Mary. But it appears that the Queen still reserved the right of preemption; Brookhause losing his cause, by a clause in the grant, which stated, that should the tinner's interest be prejudiced thereby, the lease should be forfeited.

At the time when Carew compiled his Survey of Cornwall, the tin-trade was in the hands of the London merchants, who appear, by his account, to have carried it on in a way very oppressive to the gentry, as well as to the miners. The former, he tells us, if they wanted money for a journey to London, were obliged to borrow it of the tin-merchants, with whom they were connected; upon which occasion a bond was given by them for the delivery of a thousand tin at the next coinage, for every twenty pounds received in money; although the price was usually from three to five pounds sterling higher. On the other hand, the tinner, when he wanted money, obtained it from the agents of the London merchants in Cornwall, upon terms apparently fair, but in reality still more oppressive; for although he entered into an engagement to return the lender as many thousands of tin as the money should amount to, according to the price agreed upon at the coinage; yet he was under the necessity of receiving a considerable portion of this money in meat and clothing, which articles in the settlement of accounts were charged at double their value. Nor were the

mining labourers in a better condition; for Beare, after enumerating all the wants of the tinner, and giving a statement of his small wages, exclaims, in the simplicity of his heart, 'O God! how can this man prosper!'

Such was the state of the mining interest here towards the close of the sixteenth century, when Carew compiled his Survey; but this was upon the eve of a great change for the better: for in the year 1601, there seems to have been both in and out of Parliament, a great cry against monopolies, and a bill was brought in for the purpose of restraining the royal prerogative in certain cases of letters patent. In Townsend's account of the proceedings of the four last Parliaments of Elizabeth, there is a report of the debate which took place upon that occasion, when, upon an allusion being made to the monopoly of tin, Sir Walter Rawleigh said, "I am urged to "speak in two respects: the one, because I find "myself touched in particular; the other, in that I "take some imputation and slander to be offered unto "Her Majesty, I mean by the gentleman that first "mentioned tin: for that being one of the principal "commodities of this kingdom, and being in Corn-"wall, it hath ever (so long as there were any) "belonged to the Dukes of Cornwall, and they had "special patents of privilege: it hath pleased Her "Majesty, freely to bestow on me that privilege "and that patent; being word for word the very "same the Duke's is. And because, by reason of "my office of Lord Warden of the Stannaries, I

" can sufficiently inform the house of the state " thereof, I will make bold to deliver it unto you. " When the tin is taken out of the mine, and mol- " ten and refined, then is every piece containing a " hundred weight, sealed with the Duke's seal. And " by reason of this privilege (which I now have) he " had the refusal in buying thereof, for the words of " the patent are, Nisi nos emere voluimus. Now I " will tell you, that before the granting of my patent, " whether the tin were but at seventeen shillings, " and so upward to fifty shillings a hundred, yet the " poor workman never had but two shillings a week, " finding himself. But since my patent, whosoever " will work, be tin at what price soever, they have " four shillings a week truly paid: there is no poor " that will work there, but may, and have that wages. " Notwithstanding, if all others may be repealed, I " will give my consent as freely to the cancelling of " this, as any member of this house." Townsend calls this a sharp speech, and notices the great silence which ensued.

The right of preemption continued to be exercised in the following reign: but it was not then in the hands of such a patriot; and as is usually the case with all those restraints on commerce, which have the vices of a monopoly, it was evaded. An instance of this is mentioned in a letter from the Lords of the Council to Sir Thomas Roe, our Ambassador at Constantinople, which is printed in Sir Thomas's negociations.—

" After our hearty congratulations, Whereas, com-

" plaint hath been made to the Prince his highness,
" and this board, by the farmers of the preemption
" of tin, that both His Majesty suffereth great loss
" in his customs, and that they are very much hind-
" ered by the secret exportation of tin in slabs,
" vessel in thick moulds, and into bars; whereof a
" great part is (as we are informed) brought to the
" ports of Constantinople, Aleppo, and Smyrna:
" although we have taken the best course we can
" here for the remedying of this abuse; yet we have
" thought good to pray and require you to take
" special care, that when any ships shall arrive in
" those parts, you cause diligent search to be made
" for such tin, brought without the licence of the
" farmers; and if any shall be found, to seize
" the same, satisfying the mariners for it, in some
" reasonable way; but not so as that they may be
" encouraged to use the like fraud afterwards.
" Wherein, as in all other things committed to your
" charge, we do refer ourselves to your approved wis-
" dom and discretion." Whitehall, June 26th, 1624.

Here we have another instance of the injurious exercise of this privilege; for it is evident that if the price of tin at home had borne any reasonable proportion to that, which it then amounted to in foreign markets, no such illicit trade, as is here described, could have existed.

Although the demands of the market, in those times, may be supposed to have been pretty steady; yet either the discovery of new and more productive mines, or of new improvements in mining and

metallurgy may have occasioned a surplus of tin-produce at particular periods, and, in such cases, a great depression. In emergencies like these it was natural to suppose, that the CROWN, by the judicious exercise of its prerogative, might afford relief. Hence arose several petitions, some of which were complied with; but the good which was then effected was but temporary, because the privilege was exercised either without judgement, or abused.*

Having considered the political causes, which have had some influence on our mining prosperity, I shall proceed to notice the epochs of those improvements, which have taken place in our machinery, our processes of smelting, and the mode of working, as far at least as they can be traced in the very few manuscripts and printed works, which treat of this county.

Our monarchs appear, at a very early period, to have been impressed with a notion of the superior skill of the Germans, in the arts of mining and metallurgy; and an instance is given in the Fœdera, of a licence, or passport, granted by Henry the

* If to the various causes which I have pointed out, of the alternate prosperity and decline of our tin-mines, I could add an account of their absolute produce at various periods, little would be wanting to complete their history. It is probable that some valuable information of this kind might be supplied by the records of the Dutchy; and the labour of investigation, were it undertaken by a native of Cornwall, would be well requited. All that I can obtain from printed authorities, is as follows. In the 44th of Elizabeth, according to Dodridge, the coinage duty on the tin, in the County of Cornwall, amounted to £2,502 10*s.* 9*d.* As the duty was then forty shillings on every thousand, the whole quantity of tin raised, in that year, must have been 1,250 thousands, or 625 tons.

Fourth, in the year 1402, to three persons, under whom were thirty others, all of whom were coming hither from Bohemia, Hungary, Austria, and Mysia, for the purpose of being employed in the royal mines. German miners likewise were invited by Queen Elizabeth to come over to this kingdom, some in the third, and others in the seventh year of her reign. But although there are a few terms of German origin in the language of our miners to justify the supposition, we are not informed that any of the above-mentioned persons were sent into Cornwall. It is probable, however, that the royal patronage which was given to these foreigners, and the report of their superior skill, may have induced Sir Francis Godolphin to send for the person, who is mentioned by Carew under the name of Burchard Craneigh; by the aid of whom were effected all those important improvements, which he notices in the management of the great tin-works, belonging to that gentleman. The stamps, which he describes as being then in use, and which are undoubtedly a work of German invention, appear to have been but recently introduced; for we find that they had not wholly superseded the use of the crazing mill. I suspect too, that the use of charcoal was adopted at this time, for the fusion of tin, in the place of turf, which is mentioned as the usual fuel for that purpose, in the Charter of Edward the First, anno 1305, and which continued to be so used till the reign of Elizabeth.

Without doubt the improvements, which were introduced by Sir Francis Godolphin, constitute an

important era in the history of Cornish mining: they appear, however, to have been confined to the processes of dressing and fusing the tin-ores; at least no notice is taken by Carew of any other. It would be interesting to know, when the pump was first applied to the drawing of water out of our mines; for the work of Agricola must have made it known sometime earlier than the period here mentioned. A step, no less important, was gained by the introduction of the art of blasting rocks; but this is of a much later date, for I believe it cannot be traced in this county higher than the beginning of the last century; which is a century later than the period of its invention in Germany. It was most probably first introduced into this kingdom by Prince Rupert, who must have been well acquainted with the mode of working the mines of Germany, and for some years directed the affairs of the society of the mines royal. The practice, however, of blasting may have found its way here indirectly, either from Ecton or the Peak; and the following particulars, which I have extracted from some letters, which were written to me in the year 1792, by my friend the President, while they point out the value of traditional records, will shew how early we had directed our attention to these subjects of enquiry.

June 3rd. "On the subject of blasting, what I have been able to pick up, is far from satisfactory. I only learn, in general, that it was first introduced by a German, and used at St. Agnes. It strikes me as highly probable, that this German was Becher.

If I can collect any information at St. Agnes, where I may possibly go in the course of the summer, it shall be sent you. By means of my enquiries about blasting, a curious piece of intelligence has come to my knowledge, respecting the manner in which hard ground was *spent*, previous to the use of gunpowder. It seems that they bored holes, in the same manner as at present, excepting that the bit terminated in a quadrangular point, instead of the single edge. Into these holes were put two semi-cylindrical rods of iron, or steel, called feathers, just of an equal length with the hole; and then a steel wedge of the same length, was driven between the flat sides of the two feathers, which, sufficient care having been taken to bore the hole obliquely, broke off the rock piece-meal. This wedge was called a tearer. When the ground was more than usually hard, they had no other resource, than to wear away the face of the rock, in the same way as masons cut stone for building. A large quantity of these feathers and tearers were found at Balanoon, in Lelant; but unfortunately they have been all converted into gads."

August 17th. Speaking of a conversation, which he had held with an old man, called William Hockin, on the subject of Wheal Fortune mine, he says, "The account this man can give concerning the practice of blasting is not very particular. He has heard that it was introduced by the Germans, and that all other improvements in mining came from their country; but he does not know the time when, or by whom. He once worked in a mine, which

appeared to have been left off, on account of the hardness of the ground, before the use of blasting; where, by the help of powder, they paid one half tribute, and gained £3. 3*s*. 0*d*. a month. He has heard, that Poldice mine was worked by the father of the present old Mrs. Hearle's husband, and that at that time, there was no better machine for drawing the water than a chain pump. He remembers the first whim ever built in this part of the county, on Wheal Fortune. The engine there was the third. I am in great hopes of getting some good account of blasting from an old man in Zennor; but I have not been able to meet with him."

Sept. 22nd. "I have seen the old man from Zennor, and although the information he has to give, is far short of what we hope to procure, yet even this little may be esteemed curious. He remembers having heard from his father and other old men, that blasting had been first introduced by Germans, into the eastern part of this county; and that it was brought to the west (i. e. Lelant, Zennor, and St. Ives) in their time, by two eastern men, called Bell and Case, and was used by them in Trevigha bal; and that they affected to keep the mode of operations secret, suffering no one to see them charge the holes; till a man of Zennor, hiding himself upon a bolt, saw what they were about. This he thinks must have happened about ninety years ago. He observes that, for a long time, baked clay was constantly used for tamping, till at last other materials were found to answer just as well."

Great changes were wrought in all our mining concerns by these successive improvements; but towards the close of the seventeenth century, a great revolution must have been effected in the prosperity of our tin-mines, by the discovery of a method of smelting tin, by means of pit coal, in a reverberatory furnace.

To give an adequate idea of the extreme importance of this discovery, it is enough for me to observe, that the sole fuel, which, at that period, was employed in the process of smelting tin, was charcoal; which gradually becoming scarcer, as the wood-lands diminished, could not at last be supplied in sufficient quantity to meet the growing demands of the smelter. The quantity of tin, therefore, which was brought to market, must have been, for a century at least prior to the discovery of this new process, strictly limited by this growing scarcity of fuel from the native woods; and this check on the power of production, must have been felt more sensibly by the western mines and stream-works, than by the eastern.

We are indebted for this important discovery to the celebrated John Joachim Beccher, a native of Speyer, in the Palatinate, of whose life I have collected the following particulars.

He was born in the year 1635, and losing his father, when very young, he is said to have educated himself without the aid of preceptors; nature having bestowed upon him so much acuteness of intellect, that, as Gmelin truly observes, in the account which

he has published of his life and character, had he learned a better command of his passions, or more prudence in his conduct, and had he acquired more order and precision in his ideas, his scientific labours, and his pursuits, he would have been one of the most distinguished and useful writers of his time.

A great part of his life seems to have been spent in frequent changes of his abode, which he shifted from one city to another; whenever his presence could no longer be tolerated.

In 1666, the Elector of Mayence appointed him his public lecturer on the science of medicine, in the university of that city; and soon after, his body physician. He passed next into the Elector of Bavaria's service, where he was invested with the same office, and had the use of a well-furnished laboratory at his command; but here he got into difficulties, which compelled him to remove to Vienna, where he so strongly recommended himself to the favour and protection of Count Zinzendorff, at that time president of the Aulic Chamber, and through the Count, to the whole court, by means of his projects of finance and other measures, that he was nominated a member of the newly instituted chamber of commerce, and had the title conferred on him of Imperial Aulic Counsellor. But even here he made so many enemies, and incurred to such a degree the disfavour of the court, that he was ultimately obliged to consult his personal safety by withdrawing himself from Vienna, together with his wife and family. After this, he went to Holland,

and in 1678 settled at Haerlem, when, as he had before done at Vienna, he laid before the municipality of that city, a variety of projects for making gold, some of which they appeared much inclined to make a trial of.

Whether the result, however, of these trials and experiments did not answer the expectations, which had been formed, or the reward of them fell short of what he thought himself entitled to, or his enemies at Vienna, as he pretended, continued their persecution of him, or the air of Holland ill agreed with his constitution; it is sufficient to know, that his restless disposition drove him, in the year 1680, to this island, where, after visiting the mines and furnaces of Scotland, he proceeded, in 1681, to Cornwall. He died the following year in London, and with him perished the greater part of his numerous and unaccomplished projects.

The time, and the place of his death, are given on the authority of some letters of Frederic Heyn, which are prefixed to the collection of Beccher's smaller works. Gmelin says, that examples of the reputed transmutation of the metals into each other, formed the principal subject of his numerous writings; and the discovery of the means of converting other substances into gold, the study of his whole life; the prescriptions for effecting this latter object being in fact the ground work of all his romantic projects of finance.

It is, however, admitted by Gmelin, that the genius of Boyle had a great influence in giving a better

direction to Beccher's chemical pursuits, and this indeed is perceptible in his last work, the *Alphabetum Minerale*, where a commencement is made with some success, in applying chemistry to an explanation of the great phenomena of nature. The doctrines of Beccher have also laid the foundation of that system, which was formed afterwards, with so much ingenuity, by Stahl, and which subsisted until the days of Lavoisier. This is acknowledged by Stahl in his preface to Beccher's *Physica Subterranea*, his praises of which work he says, were uninfluenced by any personal acquaintance with the writer.

Were the merits of this man, says Gmelin in his history of chemistry, to be measured by the multiplicity of his writings, the variety of departments in which he laboured, and the high opinion he entertained of himself, he would certainly take the precedence of all the philosophers of his time. In reality, however, his childish vanity made him so much the object of ridicule, that, as it often happens, the world overlooked the favourable side of his character; and, moreover, the importunity, with which he pressed on the attention of the great, his projects of improvement, as well as the language, which he had the presumption to make use of, respecting the abuse of their power, and their manifold oppression of their subjects, exposed him to their enmity. From these causes he experienced so many mortifications and disappointments, that he was constrained to wander from one country to another, in

search of tranquillity; ending his life in the midst of all these conflicts with the world, in the fifty-seventh year of his age, and in a state of great destitution.

As the name of Beccher is so connected with the history of our mining prosperity, I have presumed to think, that the above particulars would be interesting; and I was in hopes, that they comprised all the evil, which could be said of him: but the love of truth obliges me to subjoin a much more unfavourable view of his life and character, which proceeds from a man who was personally acquainted with him, and whose veracity cannot be called in question. This man is the celebrated Leibnitz. But there is so much severity in what he says of Beccher, and there is something so disgusting in the picture, which he has drawn of his profligacy, that I forbear to communicate this curious document in a translation.

"Monsieur le Docteur Beccher, medecin, etoit d'un esprit excellent, mais si malin, que la mauvais surpassoit ce qu'il y avoit de bon; et on n'auroit pas eu de peine à l'engager d'empoisonner quelqu'un, ou à commettre quelqu'autre crime semblable. Il se vantoit de beaucoup plus qu'il ne sàvoit; par exemple, d'avoir fait à Vienne l'experience de projection, quoique dans une lettre à un ami, il en parla tout autrement. Il eût même l'effronterie de faire une traité *de la langue latine,* qu'il avoit peine à parler, et à ecrire même. Il donna aussi les *Tables de Medecine,* d'un certain auteur sous le titre d' *Institution de Medecine,* en les mettant seulement de

suite, et afin qu'on ne s'appercût pas de la fraude, il fit mettre les chiffres ou l'année de son livre, comme s'il avoit été imprimé quelques années avant celui de l'auteur même. Il persuada au *Compte de Hanau*, à qui on fut obligé de donner ensuite un Curateur, qu'il pourroit être un jour *Roy d' Amerique*, et ce Compte l'envoya chez les Hollandois, pour leur demander en fief quelques terres, qui n'etoient pas en leur pouvoir de lui donner; et à son retour, il fût recu du Compte au son des tambours et des trompettes. Il'demeura aussi quelque tems à Mayence, d'ou il passa à Munich, ou il obtint une charge de Conseiller de commerce, et dela êtant entrè au service de l'Empereur; et ayant dit des injures au President de la Chambre, il y fût mis en prison, d'ou il se sauva en sautant par la fenêtre. Il mourut enfin miserablement en Cornouaille, prostituant sa propre femme et sa fille à beaux deniers comptants. Mais quelques personnes charitables eurent pitié de la fille, en la retirant de ce mauvais train. Il m'ecrivoit peu de jours avant sa mort, pour lui faire obtenir une pension de la cour d'Hannovre; mais il ne reussit pas." This account of Beccher is published in the *Miscellanea Leibnitziana*, Lipsiæ, 1719; and it appears from some chemical memorandums of Leibnitz in the same collection, that he had a personal acquaintance with Beccher.

Beccher wrote his *Alphabetum Minerale* at Truro, not long before his death, in 1682. In the dedication of this tract to Mr. Boyle, there is the following passage. "Ignis usus, ope flammarum lithantracum,

stannum et mineralia fundendi, *Cornubiæ hactenus incognitus, sed à me introductus.*" In this statement Beccher lays claim to the entire merit of a discovery, which Pryce seems to think some other persons had anticipated: but this opinion is founded on some facts, which are by no means subversive of Beccher's pretensions, but rather corroborate them. The passage in the *Mineralia* to which I allude, is as follows. "Necessity at last suggested the "introduction of pit coal for the smelting of tin-"ore: and among others, to Sir Bevil Granville, "of Stow, in this county, temp. Car. 1. who "made several experiments, though without success. "Neither did the effectual smelting of tin-ore, with "pit coal, take place till the second year of Queen "Anne, when a Mr. Liddell, with whom Mr. Moult, "a noted chemist, was concerned, obtained Her "Majesty's patent for smelting black tin, with fossil "coal, in iron furnaces. The invention of reverbera-"tory furnaces built with brick, stone, sand, lime and "clay, soon followed this discovery; the form of "which, being simple, has admitted little improve-"ment to the present time."

Here we perceive that the date of Mr. Liddell's patent was long subsequent to that of Beccher's invention; and by the term *iron furnaces*, it is clear that blast furnaces are meant: the conclusion is obvious, that Pryce must have been in utter ignorance of the prior claims of Beccher.

It will be satisfactory to know, that some memorials of Beccher are still preserved on the spot,

which was the scene of his last labours. At Treloweth smelting house, in St. Erth, there is a tradition, that the first reverberatory furnace that was ever built in Cornwall, was erected at that place; and there is some reason to believe that Beccher resided there, for his grandson's widow died in the poor house of that parish about the year 1800. Both his son and his grandson are said to have been bricklayers, although I suspect that they were so denominated, on account of their having built all the furnaces in the neighbourhood. The name of Beccher has there been long corrupted into Baker.

Beccher brought with him into Cornwall an assistant, in his metallurgical labours, a German, whose name was Loeffler, and who marrying a Cornish woman, and settling at St. Erth, survived his patron many years. He was known by the name of Dr. Luffler; and a son of this man, who was christened Joachim, probably as a mark of regard for the memory of Beccher, died at St. Erth about the year 1768, in the humble situation of village-barber.

VIII.—*An account of the Discovery of some varieties of Tin-Ore in a Vein, which have been considered peculiar to Streams; with remarks on Diluvial Tin in general.*

By JOSEPH CARNE, Esq. F.R.S., &c.

TREASURER OF THE SOCIETY.

(Read October, 1830.)

The origin of the tin-ore which, from the earliest periods of history or tradition, has been found in separate particles, or small pieces, in the lower part of the vallies, in the tin districts of Cornwall and Devon, is a subject which, whilst it excites considerable interest, is yet, like most other subjects of geological theory, exposed to several difficulties. The roundness of its particles,—their total want of connection,—the beds in which it is found,—the relation which these beds appear to bear both to the solid strata of the earth, and to the superincumbent matter,—and other circumstances, afford strong ground for supposing that the situation in which it is now found, is not that in which it was originally

placed; and that it has been exposed to the violent action of water: whilst the non-existence of tin-ore in streams, in any countries which do not abound in tin veins; and the stream tin-ore being, as well as what is usually found in veins, the oxide of tin, render it probable that, by the operation of a force out of the common course of nature, it has been separated from veins, or other depositories, in which it had originally existed, and been conveyed, with an immense mass of other substances, into the neighbouring vallies.

This theory is, perhaps, the only probable one which has ever been advanced; and yet, on account of the difficulties with which it is attended, it has been seriously questioned whether the tin of the streams was ever connected with veins or floors, and whether it has not always existed in a separate and distinct state. One of the reasons commonly given (and, perhaps, more frequently than any other) for this supposition, is the fact that stream tin often occurs in certain forms and varieties in which it has never been discovered in veins. These are, 1st. the fibrous and veined oxide, commonly called wood-tin; 2nd. the spherical or pear-form oxide, of which the fibres radiate from a centre, occurring either in separate minute masses, or in globular distinct concretions in the matrix, and when broken, forming the peculiar variety called the toad's-eye tin; 3rd. the botryoidal oxide; 4th. the spathose and resinous oxide. It has been not unreasonably argued that if these varieties have no existence in veins or floors,

(and that they have never been found there, has been considered almost a proof of this) we must look elsewhere for their origin; and in that case, we need not hesitate to look to the same source for the origin of the more common kinds of tin-ore which accompany them.

In the first volume of the Transactions of this society, Mr. Majendie mentions his having been informed that, several years before, wood-tin was found in a mine in St. Columb, not attached to the walls of the vein, but imbedded in the clay of which it was composed; but he had seen nothing of it himself.* With the exception of this circumstance, to which much uncertainty appears to be attached, I have never heard, until lately, of any of those varieties of tin-ore, except, perhaps, the last, having been found in a vein; but by the discovery, which I am about to mention, the question may be regarded as decided.

On the side of the hill which rises southward of Barius Bridge, about two miles from Penzance, on the Land's-end road, is a small tin-mine called the Garth, or, as it has lately been newly named, East Huel Cock. The slate country extends from Penzance to the foot of this hill: *there* the granite commences, and continues from thence all the way to the Land's-end. The lode of this mine is at present wholly in granite: in its course westward, it may, perhaps, intersect the slate, but it has never been seen in that connection: it varies very little

* Page 288.

from an east and west direction, and underlies southwards from one and half to two feet in a fathom, or in an angle of from 15°. to 22°. from the perpendicular: its width is very great; in the narrowest part it is nearly nine feet, and in the widest, upwards of fourteen. It cannot be doubted that the upper part of this lode was explored at a very remote period, as it bears marks of the earliest kind of mining: in one part of it there is one of those excavations (called by the miners *coffins)* so common in the most ancient mines, in which all the operations were open to the sun: the workmen could, in that way, proceed no deeper than they could draw the water with a hand pump. This circumstance makes it probable that tin* was found very near the surface. I have been informed that about sixty or seventy years ago, the heaps, which lay on the sides of the excavation, were found rich enough amply to remunerate those who *dressed* them.

Since that period, this lode has again been explored in the modern and regular way of mining: an *adit level* was brought from the valley, which when it came to the lode, was fourteen fathoms deep, and a shaft was sunk from the surface: the workmen almost immediately discovered tin in the shaft, and at the depth of five fathoms it became much more plentiful: the concern was continued to the depth of twenty-six fathoms, (or twelve fathoms below the adit) and was then abandoned, either on account of the poverty of the lode, or, what is more probable,

* By the word *tin* here, I always mean tin-ore.

for want of a better machine than a *whim* to drain the mine of water.

About three years ago, the Garth was again set at work, with an engine worked by a water wheel, for draining the water: the present workmen, on exploring the lode immediately below the *old workings*, found it productive of tin, and it has continued so to the present depth of thirty fathoms, although scarcely rich enough to pay the expences which attend the concern: the tin-ground in the lode is about six fathoms in length, and occurs directly westward of the intersection of the lode by a clay cross-course, on which the *adit* was driven: the lode has not been explored east of the cross-course.

Whether any of the peculiar varieties of stream-tin were found in this lode in the former periods of working, I cannot learn; but I have no doubt that they were, as some of them have occurred in great abundance in the small part which has lately been explored, viz. six fathoms in length, and nearly four fathoms in depth. In all this space, wood-tin, and toad's-eye tin, have been plentifully found: tin in globular distinct concretions, from the size of a pin's head to that of a pea, has occurred more sparingly; and of botryoidal tin, only a few specimens have been met with. Some parts of the lode have yielded a larger quantity than others; but in general these peculiar varieties have been most plentiful on the northern side of the lode.

Of the specimens which I have the pleasure to present to the society, Nos. 1–6, are of the lode itself:

of tin have in past times been found in veins, almost immediately below the surface of the solid strata of the earth, and even level with the clay which usually forms the uppermost coat. The Garth probably furnished an instance of this. Other instances have recently occurred. In Huel Diamond, in St. Just, tin of the first quality, in snow-white quartz, and unconnected with any other metal, has been plentifully found within a few feet of the surface. This was also the case in Kelynack in the same parish. In the valley between Nancothan and Drift, in Madron, the streamers in bringing up a channel for the river, met with two tin veins, in one of which they found a bunch of tin, which produced them upwards of fifty pounds: this was in the clay which there forms the upper part of the shelf or solid earth. In Carclase mine, near St. Austell, which nearly resembles what is termed by the Germans a *stock-work*, the tin also appears to have been discovered almost immediately under the surface. 2nd. The ochreous substance called the *Gossan* of copper lodes generally contains a small portion of tin, and it was common formerly to *dress* it for the sake of its tin: this substance occurs at the very top of the veins, and is often discovered in ploughing the fields. 3rd. That floors of tin have existed not only near the surface, but quite level with it, is as certain as tradition can make it—for there have been no recent discoveries of this kind: the spots where these have occurred are still indicated by the wide but shallow excavations which are found in some parts of the

west of Cornwall. The highest floor in the Bunny, in St. Just, is said to have been discovered by the appearance of the tin at the very surface; and a floor in a part of Botallack was nearly as shallow.

I presume these facts are sufficient to obviate this difficulty, and to shew that, in the violence of the deluge, or of any power capable of removing any part of the crust of the earth, not only the tin in the highest parts of the veins, but entire floors of tin, might have been displaced from their original situations, and deposited in the vallies.

II. "*Beds of arenaceous tin-ore have been discovered in several stream-works, under the shelf, or the solid strata: these beds, therefore, must have existed prior to the strata which cover them, and cannot consist of diluvial tin.*" This fact may be allowed without admitting the consequence, for unless it is clearly proved that the superincumbent *shelf* is united on every side to the neighbouring solid strata, and thus so completely covers the space which contains the tin, as to leave no inlet through which the tin could have been deposited underneath it, the inference drawn by the objector cannot be admitted. Now not only has no case occurred in which this has been proved; but after an extensive and particular investigation of the stream-works west of Penzance, I am convinced that the masses of *shelf*, wherever they occur over the tin, are either horizontal or slightly inclined ridges, extending from the sides of the basin or cavity in which the tin is found; or else small flat masses of slate or clay which,

although now wholly unconnected with the *shelf*, formerly formed a part of it; but were severed from the neighbouring mass by the same force which carried the tin into the valley, and at the same period. In Chyvenhall stream, in the parish of Paul, such ridges are not uncommon: the streamers give them the name of *cap-shelf*, or caps of shelf covering the tin: they are also met with in several other stream-works in this neighbourhood: the following rough section may convey some idea of them.

Suppose the space between the black lines to represent a valley in which there is a deposit of tin: the dotted part represents the tin-ground: where it is thickly dotted it is rich, and elsewhere poor. The workmen after removing the superincumbent beds of gravel, silt, &c. find a rich bed of tin at *a*, which they pursue as far as *b*, and find it become very poor: before they relinquish that part, they sink into the *shelf* below *a*, and find another bed of tin under it: should this bed not continue productive as far as the opening in the *shelf*, that part of the stream-work would, perhaps, be abandoned without discovering that the intermediate *shelf* was merely a ridge; but on taking away the tin-ground, supposing it to continue rich, the end of the ridge would appear.

Workmen not accustomed to these occurrences, would probably suppose, on coming upon one of these ridges or beds of *shelf*, that the tin-ground was terminated, and would, therefore, abandon that part of the concern: the western streamers, however, are so much accustomed to the *cap-shelf*, that they always penetrate a few feet into what appears to be the *shelf*, before they are satisfied that it is not *cap-shelf*. When they have met with tin in these situations, they have, on pursuing it, frequently discovered the termination of the ridges.

In the Carnon stream some beds of slate have been found reposing on the tin-ground, but entirely unconnected with the solid strata forming the bottom and sides of the excavation.

III. *If the stream tin has come from veins, we might expect the tin of every individual stream to bear a close resemblance to that of the nearest mines; but this is not the case.* It is allowed that this is not generally the case, although it is sometimes observable. The tin, for instance, of the Wendron mines, of Huel Trumpet, Trevenen, Huel Ann, Trenethick Wood, &c., is amongst the purest in Cornwall, and closely resembles the stream tin of the neighbouring vallies. The ore of Pentuan stream also, according to Mr. Smith's account,* bears a close resemblance to that of the veins of Hensborough hill and its vicinity: on the other hand, a considerable part of the tin of Carnon stream, which is near the Gwennap mines, is of inferior quality, and not considered as grain tin.

* Geol. Trans. Vol. 4, page 407.

But supposing such a similarity were never discoverable, can it be supposed that, in the violence of the inundation which swept the tin from the hills, it was carried only to the nearest vallies? It would rather be carried in the direction of the overpowering current. There is good reason to suppose that most of the tin, which was thus swept from the northern parts of Cornwall, was conveyed to the vallies on the the southern side of the county: this point I shall endeavour to illustrate hereafter, as it will be again alluded to.

IV. *The tin-ore of the streams is in a state of far greater purity than that of the veins, and is almost wholly used for grain tin, for which scarcely any tin-ore from veins is fit: indeed grain tin cannot be made from the best tin-ore from veins, unless the latter is mixed with a large proportion of stream tin-ore.* This is perfectly correct; but what is the principal cause of the deterioration of the quality of the vein tin? Doubtless its connection with other metallic minerals, such as oxide of iron, pyrites, sulphuret of copper, galena, wolfram, &c. Now as the whole mass, in its removal from its primary situation, must have been particularly open to decomposition, is it unreasonable to suppose that the sulphurets, and other combinations which are most liable to decomposition, were thus separated from the tin, whilst the oxides, which are least liable to it, still remain? The oxide of tin, as now found in streams, is generally free from all other metallic ores except oxide of iron.

V. *If the stream tin-ore came from veins, how is*

it that the ores of other metals, especially those of copper, lead, and zinc, so common in the veins of Cornwall, are not also found in streams? The answer to the last objection may have some reference to this also, as these ores are generally sulphurets; and in addition, may be stated the well known fact, that copper-ore rarely occurs so near to the surface as tin-ore, but is found far deeper in the veins; and, therefore, not so liable to have been swept away with the surface of the earth. Of lead-ore there is very little in Cornwall; and with respect to zinc-ore (blende), it frequently occurs in the upper parts of copper veins; and it is singular enough that some small fragments of it have been found in the Carnon stream: these, however, are of little consequence, for had none ever been met with, we might still suppose that all the sulphurets, whether of copper, lead, or zinc, had been long since decomposed.

VI. *Tin is frequently found in veins in a different earthy or stony matrix from that in which it commonly occurs in streams.* This objection is scarcely worthy of notice. The principal vein-stone of tin is quartz, and with this stone, tin is generally connected in streams: stream tin (especially the toad's-eye tin) is also often found in shorl-rock, which is so common in the granite country, both in beds and in veins, that it has been considered by some as a variety of granite:* it is particularly common at, or near, the junctions of the granite and slate. In the parishes of St. Austell and Roach, there are large tracts of

* Vol. 2, page 249.

shorl-rock intersected by tin veins, and also veins of shorl-rock containing tin, intersecting the granite, as in Carclase mine. The principal vein-stone besides these is chlorite; but this earth being much more susceptible of decomposition than quartz or shorl-rock, it is not surprizing that so little of it has been found in streams.

VII. *Native gold is frequently found in streams; but has never occurred in veins.* This objection is frequently urged, but with less reason than some of the others: the intention of it seems to be to infer that because no veins of gold have ever been discovered, nor has it been found in the veins of any other metal, it must, therefore, exist independently of veins, and if so, tin may also exist in the same way; it is, however, so far from being certain that the gold found in Cornwall is not the product of veins, that the contrary is by far the most probable; for, in the first place, no gold worthy of notice has ever been found in the western part of Cornwall: there are tin-streams in the parishes of St. Paul, St. Buryan, Sancreet, St. Just, and Madron; but I have never seen a grain of gold from any of them, nor am I aware that any has ever been found, unless,* perhaps, a few minute particles unworthy of attention. In Carnon stream, which may be called, from its situation, one of the central stream-works, a small quantity has been found; but the principal part has been discovered in the eastern stream-works of

* I must except a traditional account of a stream in St. Just, in which a minute quantity is said to have been found.

the parishes of Ladock, St. Stephens, Luxullian, &c.; we may, therefore, infer that the source of the gold is in the eastern part of the tin district of Cornwall. 2nd. Gold has been frequently found in streams *in*, and attached to, the matrix, generally quartz: I have seen several specimens of this kind: now in the case of any other metal common to Cornwall, the quartz would be without hesitation considered a vein-stone. 3rd. It has been stated, in a former communication to the society,* that in a stream-work, in the parish of Ladock, the gold is not found north of a certain line. All these circumstances render it probable, that a vein which contains gold exists somewhere in that vicinity, although it has never been discovered: this is now rendered more probable by the late discovery of so many varieties of stream tin in the vein of the Garth mine, which had never before occurred in veins.

I am not aware that any other facts or arguments, of any consequence, have been adduced against the probability of the stream tin having been derived from veins. A few facts may be mentioned which are strongly in favour of it, or which prove, at least, that the present situation of stream tin was not its original one. 1st. The situation of tin-ore in streams generally bears some relation to the width of the valley, and also to its rapid, or gentle, descent. In those parts of a valley which may be termed the *gorges*, where the hills, or the rocks, on each side, come so close as to leave but a narrow passage, there

* Vol. 1, page 236.

is seldom much tin-ore found: the currents were probably too violent to permit it to settle there. Where the descent of a valley is rapid, the whole of the tin-ore is usually found lying immediately on the *shelf;* but where it is gentle, the bed of the tin-ground is generally thicker, but not so good, as the ore is mixed up with diluvial matter; and where it is very small, the tin-ore has been found mingled with the whole diluvial mass, even within two or three feet of the surface. Chyvenhall stream-work, in St. Paul, furnishes an instance of the latter. 2nd. The spot which is esteemed most favourable to the existence of stream tin, is just at the point where one valley opens into another, at a pretty large angle: the probability is, that the progress of the currents coming down the vallies was rendered less rapid by their contact, and that, in consequence, a portion of the tin-ore settled at the point of contact. 3rd. Stream tin is often found connected with the matrix, or (as a miner would say, if he were shewn a specimen, without being aware that it came from a stream) with its vein-stone. 4th. There is a great dissimilarity in the stream tin of different districts, especially in the wood-tin: that of the St. Paul streams, for instance, bears little resemblance to that of the streams of St. Stephens or Luxullian: my inference is, that the ores came from different veins.

The peculiar situation in which nearly all the stream tin of Cornwall is found, compared with the localities of the most productive tin-veins, is highly illustrative of the direction in which the

current of the deluge swept over the surface. All the productive streams are in vallies, which open to the sea on the southern side of the Cornish peninsula; whilst most of the richest veins* are situated near the northern coast, where all the vallies open towards the north: most of those vallies have been explored; but, although small portions of tin have been found in many of them, no extensive beds have ever been discovered. The mines, for instance, of the parishes of Lelant, Gwinear, Camborne, Illogan, St. Agnes, and Perran-zabuloe, are all near the northern coast, but there are no productive streams in any of those parishes: on the southern side, however, are the streams of Perran-arworthal, Ladock, St. Stephens, Roach, St. Austell, Luxullian, &c. Now on looking at the direction which the streams bear from the mines, it will appear most probable that the course of the current, which swept the tin from its original situation, must have been from north to south, or rather from N.N.W. to S.S.E. The circumstance, already mentioned, of the gold in Ladock not being found north of a certain line, is also in favour of this fact. The same circumstance has occurred in Trethurgy moor, near St. Austell, with respect to wood-tin: it has been traced to a particular part of the moor, where it ceases to occur.† The Garth mine, which I have here described, and the stream-works in its vicinity, furnish a striking illustration of the same fact. About

* Those which are nearer the south coast, are, however, generally situated north of the streams.

† Vol. 1, page 239.

a mile north-west from the mine, and in the valley immediately below it, is the stream-work of Drift moor; but neither there, nor in any stream-works further north, has any wood-tin been found, nor scarcely any tin-stones similar to those which have occurred in the mine; but if we cross to the opposite side, we shall find, from one to two miles southward from the mine, the stream-works of Chyvenhall, Clija moor, and Kerris, in which we meet with the wood-tin, the contemporaneous tin veins, and the tin investing the quartz crystals. I possess specimens of each variety from Chyvenhall stream, which closely resemble those from the Garth mine.

IX—*On the use of Iron among the early Nations of Europe.*

By THOMAS HINGSTON, M. D.

LIBRARIAN TO THE SOCIETY.

(Read October, 1829.)

At what time mankind became first acquainted with Iron we have no certain evidence. In the earliest ages of the world, when the necessities and the arts of advanced society were unknown, many purposes, for which Iron was used in subsequent times, were imperfectly accomplished by means of various animal substances, and with instruments of wood and stone. But after the establishment of settled communities, when the wants of civil life, and the separate interests of independent kingdoms had prompted the inventions, by which their convenience and security were promoted, metallic substances were discovered, and speedily converted to those ends; and consequently, the rude contrivances, which had distinguished the first period of society, and which are still found among uncivilized nations, very soon gave place to instruments of copper, or of a composition of that metal and of

tin. For copper and tin, and indeed gold and silver, were in general use, if not while iron was unknown, yet long before it could be obtained in sufficient quantity to be made available on common occasions; as the ancients do not appear to have possessed the art of extracting it from the ore with the same facility, with which they procured the other metals.

Accordingly in the heroic ages, their domestic utensils, and their instruments of warfare, consisted of brass, or to speak more correctly, of bronze; of which also the tools of their artificers were made, and nails and bolts, and, indeed, every article of that kind employed in the building of houses and ships. Thus, when Hecamede provides an entertainment for Nestor and Machaon, she places on the table a a brazen dish, and scrapes the cheese with a knife of brass.* And Ulysses, when he prepares for his departure from Ogygia, hews the timber, and builds his vessel, with tools of the same material.† And in like manner, the wood for the funeral pyre of Patroclus was cut with brazen axes.‡ Indeed the story, which relates the invention of the saw, describes it as having been made of iron: but besides the improbability arising from the general custom of employing bronze for such purposes, the account is rendered still more questionable by the fact, that the inventor lived at a period, when iron was hardly known in Europe, and was, therefore, too scarce and costly to be used in a mere experiment, which the making of the first saw seems to have been.§ With

* Hom. Il. xi. 629. 639. † Hom. Od. v. 234. 244. ‡ Hom. Il. xxiii. 118.
§ Ovid. Metam. viii. 244. Senec. Epist. 90. Diod. Sic. iv. 5.

respect to the offensive arms in use at that early time, the circumstance of their being made of bronze, is so frequently mentioned, and so well understood, that it is unnecessary to quote any particular example.

In accordance with these facts, to which some direct reference, or incidental allusion may be found in most of the ancient writers, it may be observed that almost all the weapons and utensils of the primitive ages, which have been accidentally discovered at different periods, and in various places, or have been preserved and transmitted to the present times, have been found to consist of the same composition of tin and copper. Thus we are told by Plutarch in his life of Theseus, that when Cimon found the bones of that hero in Scyros, there was a sword also in the grave, and a brazen headed lance.* And similar discoveries have been made in the ancient burial places of this county, as in the year 1716, at Mên, in Sennen: and likewise in the tin-works at different places, as in the instance mentioned by Leland, which occurred at St. Hilary; and in another case, which Hollinshed describes as happening in the neighbourhood of Mousehole, where the workmen found spear-heads, swords, and battle-axes of copper.† So also in an ancient tumulus, near Mycenæ, in Peloponnesus, usually called the brazen treasury of Atreus, bronze nails are said to have been occasionally found; and knife-blades of the same metal may be procured among the pyramids and catacombs of Saccara.‡

* Plut. in vit. Thes.

† Carew's Surv. of Corn. by Lord de Dunstanville, p. 381. Borl. Ant. of Corn. p. 238. 283. ‡ Clarke's Travels, v. 241. vi. 493.

Indeed, with the exceptions to which I shall afterwards refer, copper was probably employed for all the ordinary occasions, to which Iron is applied in the present day: and it seems to have been so used, even after the art of manufacturing Iron was well understood. For when Herodotus says, that the people of Æthiopia confined their prisoners with chains of gold, from the great scarcity of copper in that country, whatever might have been the truth of the story, we must believe, that copper was still used for such purposes in Greece; and the more so, as Heliodorus, who wrote many centuries afterwards, ascribes that custom of the Æthiopians to the want of Iron, which long before his time must have been the metal in general use.*

There can be no doubt, however, that Iron was known at a very early period. It is one of the first metals of which mention is made in authentic history; for Tubalcain, the son of Lamech, is described as *the instructor of every artificer in brass and iron.*† To what extent it was used in those remote times, we have no means of determining: but in the age of Moses, it seems to have been possessed in considerable quantities, and employed for all ordinary purposes, by most of the civilized nations of the east. It is accordingly often noticed in the writings of that historian, and of his successor; and we learn, that

* Herod. iii. 23. Heliod. Æthiop. ix. Homer, indeed, speaks of iron chains in the first book of the Odyssey, but it does not follow that they were actually used in that age: for he merely makes Minerva say that the return of Ulysses is so certain, that even bonds of iron would not detain him. Od. i. 203.

† Genesis, iv. 22.

among the ancient inhabitants of Canaan, and among the Israelites, who supplanted them, the woodman, and the stonehewer obtained from it their hammers and axes; and the warrior, his sword and his chariot.* Yet it is remarkable, that, although Iron and brass were in common use among the orientals at so early a time, the expedients which are necessary, where those substances are insufficiently obtained, or entirely unknown, continued to be practised in some degree by the Persians till a comparatively late period, when indeed such contrivances had long ceased even in those countries, where the opportunity of substituting better methods did not occur so soon. For on the plain of Marathon, at this day, may be found arrow-heads of common flint; and that they were shot by the Persian bowmen, in the battle for which that place is celebrated, follows of necessity from the fact, that in the army of the Greeks there were no soldiers of that denomination. According to Æschylus, indeed, who was himself at Marathon, the Asiatics always depended much on the number and skill of their archers, and were distinguished from the Greeks chiefly by that circumstance.†

But in Europe Iron was not generally used till a later æra. In the heroic ages, as we have already seen, copper was almost universally employed in the fabrication of weapons, and instruments of every

* Deuteron. xxvii. 5. Καὶ ἐκπεσὸν τὸ σιδήριον ἀπὸ τοῦ ξυλου τύχῃ τοῦ πλησίον, καὶ ἀποθάνῃ. Deut. xix. 5. (vers. Sept.) Numb. xxxvi. 16. Josh. xvii. 16. 2 Kings, vi. 6.

† Herod. vi. 112. Æschyl. in Pers. Clarke's Travels, vii. 23.

kind for which a metallic substance was necessary; and consequently many have supposed that Iron was in those times either wholly unknown, or never applied to any useful purpose. This opinion, indeed, which we shall presently find to be incorrect, is somewhat supported by the fact, that copper was the first metal with which the primitive Greeks became acquainted: for all those who have made any reference to the question, and especially Hesiod, Lucretius and Ovid, concur in maintaining the subsequent introduction of Iron.*

Yet it does not appear, that the interval was considerable: for Cadmus, who first instructed the Greeks in the nature and uses of copper, came into Europe about 1493 years before the present epoch; and the Dactyli, to whom they were indebted for their knowledge of Iron, are said to have settled in Crete in the reign of Minos the first, who was the son of Europa, and therefore a nephew of the same Cadmus.† The use of these metals in Greece must, therefore, have been contemporaneous almost from the beginning; and the less frequent employment of Iron, which has given rise to the opinion, that it was unknown in those times, must be ascribed, as we have said before, to the great difficulty of reducing its ores, among a people so imperfectly skilled in operations of that kind.

But notwithstanding the preference, which on that

* Hesiod. Op. et D. i. 149. Lucret. de Rer. Nat. v. 1286. Ovid. Fast. iv. 405.

† Hygin. Fab. 274. Strab. xiv. Diod. Sic. v. 4. Plin. H. N. vii. 57. Senec. Epist. 90.

account was given to copper, the superior properties of Iron were not overlooked; and as early as the Trojan war, the art of working it had been so far advanced, that we find some examples of its use, in the account of that celebrated enterprize. Thus the arrow, which at the instigation of Minerva, Pandarus shot at Menelaus, was barbed with iron; and Nestor relates among the adventures of his youth, the victory which he achieved over Ereuthalion, who used to commit great slaughter with an iron-club.*

Yet there is good reason to believe, that in those ages Iron was still scarce and precious. In the games which Achilles celebrated in honour of his friend, one of the prizes was a ball, or probably a coit, of cast-iron.† And somewhat before this, when Euneus sent, from Lemnos to the Grecian camp, a fleet of ships laden with wine, the Greeks bought it with bronze and iron‡ In these cases the iron must have been valuable for its scarcity and its intrinsic properties; and the mixed metal, as it was very abundant, must have become an article of traffic merely from the greater facility, with which it might be manufactured and applied to useful purposes. What, indeed, was the relative worth of Iron at that period, I do not know that we have any means of deciding: but it seems, that the value of bronze, compared with that of gold, was something less than

* Hom. Il. iv. 123. vii. 136. See also Il. xviii. 34. xxiii. 30. Odys. xvi. 294.

† Σόλος αὐτοχόωνος. Hom. Il. xxiii. 826.

‡ Hom. Il. vii. 472. See Odys. i. 184.

as one to eleven. For when Glaucus gave his armour for Diomed's, Homer describes it as being equivalent to the exchange of a hundred oxen for nine.* We may suppose, indeed, that the armour of Glaucus was not formed entirely of gold, but merely ornamented with that metal; yet whatever was the fact, it is very likely that Homer meant it to be so understood; and in that case, though the poet might not have made a very scrupulous calculation, we may receive his account as sufficiently shewing the comparative value of those metals in his own day.

But the esteem, in which iron was held for its essential properties, continued long after the time, of which we have been speaking: and accordingly Rhodopis, who had been married to the brother of the celebrated Sappho, and must, therefore, have lived about six hundred years subsequently to that period, did not think a certain number of iron-spits an unworthy offering to Apollo at Delphi.† Soon after this, however, as the art of working it improved, and its fitness for ornamental purposes became known, it began in some degree to be recommended by the extrinsic and accidental value conferred on it by the hand of the artisan: for the silver-cup, which Alyattes the second, king of Lydia, who was nearly contemporary with Rhodopis, presented at the same altar, is said to have been furnished with an iron-stand so skillfully cemented, that it was reckoned

* Hom. Il. vi. 236. † Herod. ii. 135.

among the most valuable treasures of the temple; and Herodotus has recorded the name of the workman, who contrived it.*

Homer, however, was evidently acquainted with the common mode of hardening Iron; for he tells us, that when Ulysses thrust a burning stake into the eye of Polyphemus, it hissed as Iron does, when it is strengthened by immersion in cold water:† and, indeed, if Sophocles has not committed an anachronism very common among poets, that operation must have been practised by the Greeks at a still earlier time; for he makes Ajax, who was the contemporary of Ulysses, derive from it a simile descriptive of the past obduracy of his own mind.‡ To the Egyptians the art was undoubtedly known in a very distant age; and every one, who has observed with what freedom and precision their monuments of granite and porphyry are sculptured, must have seen that they could communicate a degree of hardness to metals, which may not, perhaps, be attainable by the skill and science of modern days. From Egypt, therefore, it is probable, that many improvements in the process of tempering Iron were introduced into Europe: for after some intercourse with that country had been established by the Greeks, many of whom expressly travelled in the pursuit of knowledge, we find that the Grecian lapidaries practised their art with instruments of Iron: though, indeed, in the time of Theophrastus,

* Herod. i. 25. † Hom. Od. ix. 393.
‡ Soph. in Aj. Flagell. 664.

the mode of hardening that metal was still so imperfectly understood, that in many instances such tools were insufficient for the purpose; and they were consequently obliged, as in our own time, to cut one stone with another.* Yet even then the art seems to have been considerably advanced; and the exquisite temper of the armour made by Zoilus the Cyprian for Demetrius Poliorcetes, on which a dart shot from a catapult made no impression, indicates a degree of skill, which probably has never been surpassed.†

At what time the Greeks became acquainted with Steel, properly so called, is uncertain; nor am I disposed to think that the most careful and extensive enquiry would afford any chance of determining the question. For it does not appear that they distinguished it by any specific appellation; and besides the name, which it therefore received in common with pure Iron, the word *Adamas* likewise, by which many suppose it to have been particularly denoted, was equally applied to the magnet, and the diamond. Some, indeed, have thought that the diamond was not called *Adamas* till a very late period; and even the elder Pliny has been quoted as the earliest authority for that use of the word: but it was so named by Theophrastus, who lived four hundred years before him; and there is no reason to believe, that the diamond was not known by the same denomination, to those who flourished

* Theophr. περὶ Λιθ. 12. 72. 75.

† Plut. in Demetr.

at a still earlier day.* Plato, also, gives the same appellation to a substance, which he describes as remarkable for its density and blackness, and which after the mechanical detachment of the earthy matter from the ores of gold, he supposes to exist in a state of more intimate combination with that metal, and to be capable of separation only by fire.† In fact, *Adamas* seems to have been a general term applicable to every thing distinguished by its hard and intractable qualities,—in the natural world signifying all substances so compact and obdurate, as to resist the ordinary operation of external agents; and in the moral world, affording a point of comparison, to which the heathen referred the certainty of oracular predictions, and the christian the firmness and the immutability of his faith. The Pythia at Delphi declares to the Athenians that her word is surer than *adamant;* and Origen exposes and refutes the heresies of the primitive church by the mouth of *Adamantius.*‡ A word, therefore, so unlimited in its application, though it be sufficiently determinate in its meaning, is a very inadequate guide in an enquiry of this kind; and as steel was denoted by it only in common with other hard bodies, we cannot ascertain in what degree that substance was known to the Greeks.

After the time of Homer, the employment of Iron in the manufacture of military instruments became

* Theophr. ib. 22.

† Plat. Polit. in Op. Gran. p. 558. Tim. in Op. p. 1066.

‡ Herod. vii. 141. Orig. Dialog.

gradually more common, and at length entirely superseded the use of copper or bronze. This circumstance, besides the more direct evidence by which it might be shewn, may be distinctly traced in those modifications of the mythological system of the Greeks, by which they adapted it to the ordinary advancement of knowledge and the arts. For when, in imitation of the Persians, who described the seven gates of the sky as consisting of so many metals, and each occupied by its presiding divinity, the Greeks consecrated each of the metals to some god, according to a real or fancied analogy between the qualities of the substance, and the nature of the deity; they dedicated bronze to Mars, and Homer accordingly denominates him the brazen god.* But when the fitness of Iron for the occasions, over which that divinity was supposed to preside, became better known, they gave both to him, as equally the instruments of his dominion.† And at length, when the use of copper, and its compounds, was altogether discontinued among soldiers, except for purposes of shew and embellishment, that metal was appropriated entirely to the goddess of beauty, and Mars became merely the iron-god.‡

With respect to the use of Iron in the arts of peace, and the ordinary occasions of common life, the same circumstances are equally observable. The primitive ploughshare, and in fact, all the

* Hom. Il. vii. 146. So also Pind. Od. Olymp. x. 19.

† Σιδηρος δὲ καὶ χαλκὸς πολέμων ὄργανα. Plat. Leg. xii. Op. p. 991.

‡ Didym. in Hom. Il. v. 385. Schol. in Pind. Od. Isth. v.

agricultural implements of the first ages of the world, seem to have been made entirely of wood: and consequently, what Virgil declares of Ceres, and Tibullus of Osiris, must be referred to the liberty, which poets have always exercised, of departing at their convenience from the strictness of historical truth: for though in the literal acceptation of their words, they say no more than that Ceres, and Osiris, first employed Iron in the cultivation of the earth; yet every scholar knows, that their design was to relate that fact as the introduction of agriculture itself.* It is remarkable, however, that in our own times the celebrated Fourcroy has fallen into the error, which, from the privilege of their order, we cannot impute to the poets of antiquity: for without thinking of the substitutes for Iron, which were everywhere about him, and which in early times had been actually used, he does not hesitate to say, that agriculture owes its very existence to our knowledge of that metal. But he was probably better acquainted with the science, which he so laudably advanced, than with the remote history of the substances, which are the subjects of its operations.

To the use of wood succeeded that of copper or bronze, and afterwards of Iron, as in the cases already mentioned. But at what time Iron was first applied to agricultural purposes, or when it entirely superseded the use of copper, we have no means of knowing. It seems, however, to have

* Virg. Georg. i. 147. Tibull. El. i. 7. 29.

been so employed at a very early period: for when Achilles at the funeral games of Patroclus, proposes, as we have said before, an iron-sphere or coit as the reward of him, who should throw it farthest, he represents it as enough to supply the wants of an extensive farm for five years; and we may, therefore suppose, that Iron was, at least sometimes, employed in agricultural operations even at that day.

In connection with this part of the subject, it may be observed, that the earlier ancients made no use of Iron in the manufacture of horse-shoes. The hoofs of their horses were entirely exposed, according to the custom of some eastern nations at the present time. The consequence of this was, that in their military expeditions, the cavalry was frequently disabled, and in such cases they were compelled to conduct the enterprize without it.* The only remedy against accidents of that kind was supposed to consist in some mode of increasing the natural hardness of the hoof; and various means were, therefore, devised and recommended. To this circumstance, I presume, we should refer the epithet *single-hoofed*, by which Homer constantly describes the horses of his heroes, as the chief recommendation of a horse must have been a solid and unbroken hoof.† In after times, the hoof was very ineffectually defended with a kind of sock, which might be

* Judges, v. 22. Diod. Sical. xvii. 10. Appian. de Bello Mithrid. Quint. Curt. viii. 2.

† —ἐλάσσῃ μωνυχας ἵππους. Hom. Il. v. 226. So Virgil. Georg. iii. 88. —*solido graviter sonat ungula cornu.*

taken off and replaced at pleasure: and in fact, as we learn from a passage of Catullus, it was so loosely fastened, that in passing over a marshy soil it was sometimes lost.* The under part of this covering was occasionally made of Iron; the upper part, which ascended to the top of the hoof, being fabricated according to the taste or wealth of the proprietor: and accordingly, we are told, that Nero, who was fond of horses from his youth, was satisfied with nothing less than silver for that purpose; while Poppæa, his wife, caused her favourite horses to be shod even with gold.† From this practice, which seems to have continued to a very late period, we may perhaps, obtain an explanation of the well known story of Julius Cæsar's horse, the hoofs of which are said to have had toes, like the human foot. For as this mode of covering the hoof would have enabled him to bestow on his horse that extraordinary distinction, he might have actually done so, with the design of propagating among the credulous people, who submitted to his will, some delusion, in support of the superstitious pretensions to absolute dominion, which he had made on the authority of the haruspices.‡ At what time, however, deceptions of this kind became no longer practicable, from the introduction of the present mode of nailing an iron-shoe to the bottom of the hoof, cannot be determined with any degree of certainty. By some, indeed,

* Catull. xvii. 26.

† Sueton. in Neron. 22. 30. Plin. Hist. N. xxxiii. 11. 49.

‡ Sueton. in Jul. Caes. 61.

the origin of that practice is referred to the ninth century: though in our own county it seems to have been but partially adopted till a period comparatively recent; for we are informed by Carew, that in the remembrance of some, who were yet living in his time, the Cornish shod their horses on the forefeet only.*

These facts, which might be easily accumulated in greater number, sufficiently shew the difficult and gradual application of Iron to general purposes in the south of Europe; and it will be found, that similar circumstances attended its introduction among the nations of the north. It cannot be necessary, therefore, to pursue this part of the subject in detail; and I shall advert only to a few of the more prominent and remarkable facts, and especially to those, which belong more particularly to our own country.

Among the Scythians Iron was known as early as the age of Herodotus, and he expressly says that they used no copper. But whether they were really acquainted with copper, and whether among them, as in other nations, it had occupied the intermediate stage between the employment of sharp stones and of Iron, the expression, which he uses does not distinctly indicate.† On the other hand, he mentions

* Carew's Surv. of Corn. p. 83. Since writing this paper, I have found that some of the facts, which I have detailed on the subject of horse-shoes, are mentioned by Bishop Lowth in his Commentary on Isaiah, with the addition of a few particulars, of which I have not spoken. To him, therefore, and to Beckman, who follows him, I beg to refer the reader for the supply of my omissions.

† Herod. iv. 62. Ἀργύρῳ δὲ οὐδὲν οὐδὲ χαλκῷ χρέωνται. ib. 71.

the Massagetæ, who are sometimes confounded with the Scythians, as possessing no Iron whatever, and as employing copper for all ordinary occasions.* Dr. Borlase, indeed, informs us, that the same fact was observable among the Germans, even as late as the first century of the christian æra; for he says, that they had no Iron in the time of Tacitus.† But this statement of the learned and venerable antiquary is by no means consistent with the account, which we have received from that historian himself. For though he speaks of the infrequency of iron-weapons among the Æstii, and of the more general use of clubs for that reason; yet from what he says of the Catti, it appears, that among them at least instruments of Iron were sufficiently common, and he particularly mentions their custom of wearing an iron-ring, till they had killed an enemy. And what is still more to the point, he describes one of the districts of Germany as having iron-mines.‡ But long before Tacitus wrote his account of the Germans, Iron so abounded in Gaul, that as we learn from Cæsar, the Veneti moored their ships with iron-chains, instead of the ordinary means.§

To the Britons, also, Iron was known quite as early: and though at the time of Cæsar's invasion it seems to have been scarce; yet he enumerates it among the natural productions of the island.‖ Like the Spartans in elder times, our forefathers used it

* Herod. i. 215. † Borl. Antiq. of Corn. p. 290.
‡ Tacit. de Mor. Germ. 30. 31. 43. 45.
§ Cæs. de Bell. Gall. iii. 13. ‖ Cæs. ib. v. 12.

as an instrument of commerce; and about a hundred years ago, some specimens of the rude coinage mentioned by Cæsar were found in considerable quantities in this county.* It is probable, however, that they had money of other kinds: for besides that of copper, which Cæsar expressly mentions, Strabo and Tacitus speak even of gold and silver as among the mineral treasures of the country; and it is, therefore, to be presumed, that they were at least among the possessions of the inhabitants.† Cicero, indeed, had been informed, that neither of those metals was to be found in Britain; but it is likely, that the accounts to which he refers, were contradictory only of the report then prevailing in Rome, that the mines of the country abounded with them.‡

With regard to Iron, however, it appears to have been rare and precious, even as late as the beginning of the third century: for at that time, according to Herodian, the Britons wore iron-belts and collars, for the two-fold purpose of ornamenting their persons, and displaying their wealth.§ And although, as in other countries, it must have come into more general use, when it was obtained in greater quantities; yet there seems to be some probability, that its application to many purposes, for which it was known to be available, was for a time restricted by certain considerations connected with the religious

* Borl. Antiq. of Corn. p. 275. † Strab. iv. Tacit. in vit. Agric. 12.
‡ Cic. Epist. ad Fam. vii. 7.
§ Herodian. iii. 47. Iron-rings were in use among the Romans till a very late period. Plin. H. N. xxxiii. 1. Juvén. Sat. xi. 128.

system of the Druids. Their sacred herbs were supposed to be polluted by the contact of Iron; and consequently, no instrument of that metal was ever employed in the mystical formalities of the annual gathering. It is, therefore, to be presumed, that while the use of Iron was discountenanced by the national religion, from the belief, that it would corrupt its objects, and invalidate its ceremonies, some hidden and mischievous qualities would be thought to reside in the nature of the metal itself; and the people would be disinclined to use it even on common occasions, if a convenient substitute could be obtained. Peculiarities of this kind, indeed, appear to have existed in the early institutions of other countries, and might have been more or less productive of the same effect. When the Jewish lawgiver was commanded to build an altar of stone, on that occasion the use of iron-tools was strictly forbidden. In this case, however, as the altar was directed to be built with unhewn stones, and as tools of every kind were, therefore, not to be employed, it is likely that the injunction referred rather to the the danger of introducing artificial forms into the religious services of a people so strongly disposed to idolatry, than to any unfitness in the natural properties of Iron.* But for the rejection of Iron in similar cases among the heathen nations, I do not know that so satisfactory an account can be given; and the instances, which are recorded, may be imputed to craft or superstition. The Egyptians

* Exod. xx. 25. Deut. xxvii. 5.

incised the body for the embalmers with a knife of stone; and with the same instrument the Romans slew the victim in the ratification of their treaties. The priests of the Sabines pretended, like the high priest of Jupiter at Rome, that their hair was not to be cut, but with an instrument of brass; and knives of the same substance were supposed to be necessary in collecting plants for the arts of the magician.*

A prejudice of this kind would easily extend itself beyond the circumstances, to which it might at first be limited; and it was at length believed, that those qualities, which could stain the purity of a religious service, would weaken the efficacy of medicine. Serenus Sammonicus thought that the bark of the alder would lose its virtue, if it were collected with an iron-knife; and Galen imagined, that certain medicines would be rendered useless, if they were compounded by any one having Iron about his person. This distrust at last ripened into the belief, that Iron was actually poisonous; and long after the time of Galen, we find Avicenna so much afraid of the pernicious effects of its reception into the stomach, that he recommends as an antidote the immediate administration of a magnet, unconscious that he was merely directing a second dose of the imaginary poison.

It had, indeed, been supposed from an early period, that wounds inflicted with iron-weapons would not readily heal; and I am tempted to think, that some

* Virg. Æn. iv. 513. Macrob. v. 19. Serv. ad Æn. i. 448.

consideration of that kind might have influenced Marcus Antoninus, when in his design to mitigate the severity of the gladiatorial exhibitions, he forbad the use of sharp weapons. Xiphilinus imputes it to his dislike of slaughter: but as from the same account, we learn that he permitted the combatants to use blunt weapons, their encounters must have been more dangerous and destructive, than the historian supposes; and the prohibition may be reasonably referred to some other cause.* To this opinion of the poisonous qualities of Iron, Bishop Watson is inclined to ascribe that article in the treaty of Porsena with the Romans, in which, according to Pliny, it was expressly stipulated, that they should discontinue the use of Iron, except in the manufacture of agricultural implements. But we have no evidence, that such properties were at that time ascribed to it; and the fact seems to admit of a very different explanation. For whatever may be pretended by the other historians, Tacitus acknowledges that Porsena subdued the Romans, and obtained possession of their city; and it is possible, therefore, that he exacted the stipulation in question, as the Romans themselves did afterwards in the case of the Ligurians, not from any fear of the poisonous nature of Iron, but that he might secure and continue their subjection, by depriving them of the most effective means of resistance.†

Such are some of the more remarkable facts, which

* Xiphil. in vit. Marc. Anton. 6.

† Plin. Hist. Nat. xxxiv. 14. Tacit. Hist. iii. 72. Florus de Reb. Rom. ii. 3.

I have collected with respect to the use of Iron, among the early nations of Europe; where, as we have seen, it became known, long after it had been in general use in the east. The scattered notices, which exist on the subject, are somewhat obscured, and the enquiry has been consequently embarrassed, not only from the practice so common among poets and historians of describing the events of remote times, according to the state of the arts in their own age; but from the contrary custom of designating the workers in Iron and brass by the same appellation: for when the manufactures of Iron were not such as to require a distinct class of artificers, they constituted only a part of the general business of the copper-smith; and hence the term, by which his proper and more ordinary employment was strictly described, was equally applied to such occupations as were merely subordinate and occasional.*

These difficulties, therefore, may be allowed to explain and extenuate, in some degree, the imperfect success with which the investigation has been prosecuted. There could be little hope, indeed, that on a subject so restricted to times far distant, and to customs indistinctly described, some questions would not be insufficiently pursued, and some accidentally neglected; and my purpose, therefore, has been less to satisfy curiosity by the fulness of the present enquiry, than to stimulate it to others of greater labour, and of higher interest.

* Χαλκέας, τοὺς τὸν σίδηρον ἐργαζομένους. Arist. Poet. 46. See Hom. Odys. ix. 391.

X.—*On a very singular Deposit of Alluvial Matter on St. Agnes Beacon, and on the Granitical Rock which occurs in the same situation.*

By JOHN HAWKINS, Esq. F.R.S., &c.

VICE PRESIDENT OF THE SOCIETY.

(Read October, 1830.)

In Cornwall alluvial deposits are usually found in vallies, where they have been transported from higher levels. The fragments of rock, which compose them, are rounded more or less, by attrition, or in other words, by a long exposure to the violent action of water. I have traced some of these fragments so deposited, to the distance of several miles from the beds or lodes which produced them. But it is not so easy to account for the situation of one of these alluvial deposits on a high insulated and conical hill, such as that of St. Agnes beacon.

Dr. Borlase is, I believe, the first writer, who has noticed this singular phenomenon, as well as the remarkable fact, that the alluvial tin is here covered with a formation of sand and of pipe clay. We have no other example in this primitive country, of such a formation. It occurs only in countries of more recent origin.

The existence of the alluvial fragments of rock here, has long been known in Cornwall; and it has been regarded as a remarkable fact which merited attention; but there are few persons, I believe, who have been induced to visit the spot, in order to obtain a perfect knowledge of all the circumstances under which it occurs; at least, it has not been in my power to collect from others those particulars, which alone can enable us to draw any just conclusions with regard to the origin of such a deposit.

The following particulars are the result of a visit which I lately made to St. Agnes for that purpose.

The deposit of sand, clay, and alluvial fragments of rock, occurs at an elevation of three hundred and seventy-five feet* above high water at spring tides, and it mantles round the base of that central eminence, which is commonly called the Beacon. Beneath it, in the killas rock, are some of the richest tin lodes, which have been worked in this county.

The greatest breadth of this deposit, which amounts to one hundred and fifty fathoms, is situated on the eastern side of the beacon. It gradually contracts on the northern to seventy fathoms, and vanishes about half way in its progress along the western side. Its surface presents one uniform line of inclination on all these three sides of the beacon.

* According to Dr. Berger's barometrical measurement, the height of St. Agnes beacon is 664 feet; but in the account of the great trigonometrical survey of this part of England, it amounts to 599 feet only. Of the accuracy of this last statement I entertain some doubt: this, as well as most of the other heights used in the survey, having been deduced from two very remote stations. It is extraordinary that such an opportunity should have been omitted of repeating the operation, which was used upon those two occasions, that of levelling down to low water mark.

Several pits have been sunk through the beds of this deposit for the extraction of the white sand and clay, which are applied to various uses. The first which I visited lay near Trevaunance, and close by a mine, which is called Wheal Gobe. Here, beneath the vegetable mould, I found a deep bed of what is called yellow cobb mixed with rubble, not materially differing from that which usually covers the killas rock. This was succeeded by fine clay in a bed of two feet, then by clay and sand to the farther depth of three feet, and ultimately by a fine white grit sand, the depth of which had not been ascertained.

On the edge or margin of this deposit, where it joins the base of the beacon, the beds of clay and sand are said to disappear rather suddenly, and the rubble alone remains. Here, at a spot called Opie's Field, where the rubble is, for the most part, twenty feet deep, has been found, immediately beneath it, and on the surface of the bare rock, no small quantity of alluvial tin, in fragments of all sizes, one of which, a mass of rock with rounded angles, is said to have produced twenty-one hundred weight of black tin, and to have been found lying only twelve feet below the surface of the rubble. I saw here (perhaps at a higher level of the hill, where the alluvial beds were not so thick) a considerable number of boulders, or large fragments of rock, worn smooth by alluvial attrition, which had been found in the same situation with respect to the surface of the rock.

The next pit which I examined, was one which had been sunk in the new downs, as it is called, on

the north side of the beacon. Here I found the yellow cobb, two feet and half in depth, mixed with a great proportion of rubble, all of which was composed of the hard quartzy-veined killas, here called caple. This bed underlies with the hill to the north. The next to it, in succession, was a bed of brown sand, which attained a thickness of nine feet. This bed underlies also to the north, but has numerous sedimentary divisions, which dip in an angle of 45°. to the south. Then occurred nine or ten feet of bluish gray, and brown clay, some portion of which had a slight mixture of carbonic matter. This bed is capped with four or five inches of white clay. The pit-man takes only the clay, which is one foot deep here, for the use of the miners, because what lies deeper is mixed with too much sand for the purpose to which it is applied. Below this sandy clay they find grit-sand six or seven feet deep, until they reach the rock, which is said to be even and naked. The entire depth of the deposit to the rock is twenty-four feet, but its breadth here does not exceed seventy fathoms, and it abruptly ceases, on the side of the beacon, being cut off by a sort of bank or cliff, although there is nothing on the surface of the ground, which indicates such an interruption.

From the father of the pit-man, who worked here, Capt. James Stephens, I subsequently procured the following general information respecting these beds.

Immediately beneath the vegetable mould lies from two to three feet of cobb, pretty free from rubble or other matters.

Then from three to four feet of yellow sand, which is succeeded by fourteen inches of mining clay.

After this comes four and half, or five feet of white sand, and then from two to three feet of yellow sand. Next occur pebbles of a flattened shape, which are a few inches in breadth, resting on two or three inches of what he calls black mud, which is in contact with the surface of the rock.

Capt. Stephens added, that the sand and clay deposit extends for some distance along the western base of the beacon, preserving a breadth of about forty fathoms, and there the beds are as follow. First, under the vegetable mould, yellow cobb, mixed with much rubble four feet deep, then clay, which has a thickness of six feet, after which succeed two or three feet of what he called *puddle* sand.

This deposit terminates likewise on this side as you approach the beacon, as abruptly as it does on the north side. It observes the same level on the west as on the north of the beacon, and on these sides no stream-tin has been found beneath it.

As for the stream-tin, which has been found on the eastern side, it occurs sometimes on the smooth surface of the killas rock, more abundantly in the hollows, which have been formed on it, apparently by the action of running water, and always beneath the larger masses of rock which are scattered over it. Capt. James Stephens, who communicated these particulars, omitted to mention the occurrence of sand-stone between the beds of clay and sand on the north of the beacon.

St. Agnes beacon is certainly a very remarkable hill, for it is the most insulated of any in this county, and the line of descent is unbroken in every direction until it reaches the common level.

About one half of the periphery of its base is bordered by the sea. A rapid descent into two narrow vales, which communicate on two opposite sides of the hill with the sea, forms a sort of natural boundary, for the space of another quarter of its periphery, and the remainder has, at a remote period of time, been very strongly fortified. The area within these boundaries contains twelve hundred and thirteen statute acres, and a small portion of it, not exceeding one eighth, has produced more tin than any spot, of the same extent, in this county.

The lodes run through killas, and when we consider how numerous they are, and how rich they have proved, it appears extraordinary that they should occur at so great a distance from the central hills of granite, which mark so invaribly in all other districts, the vicinity of those lodes of tin and copper, which are the chief objects of mining adventure. I have, therefore, for a long time entertained a suspicion that granite, in some shape or other, constituted the basis of this great hill, and this suspicion has in part been verified; for a considerable portion of the more extended flanks of the hill on the north-western side of the beacon, consists of a sort of rock, which, without being decidedly growan or elvan, participates of the nature of each, and is here called growan. The quartz and the feltspar are in part so

finely and intimately mixed in the composition of this rock as to resemble the paste of some porphyries, but larger crystals of each lie interspersed in it, and these in proportion as they attain a greater size, become fewer, those of feltspar being the largest. The mica is nearly wanting.

This compound rock, which occurs on the northern and north-western flanks of the hill, and at a lower level than the sand deposit, extends in a north-eastern and south-western direction. It protrudes no where above the surface of the ground, except in the form of scattered masses; but it has been the seat of much mining adventure at some early period, for it abounds in tin-lodes, one of which has been worked out from the surface to a considerable depth: the two smooth walls being left untouched. At this spot, which is called Wheal Coates, from some renewed attempts to open a mine, I found a person of experience, from whom I collected the following particulars.

The beds of the growan underlie a little to the north, and several parallel lodes, which are for the most part very small, run through them. These lodes differ not from those which are so usual in growan, being composed of quartz and schorl, with a little tin. They have an east and west direction, and are supposed to extend through the beacon, which is composed of killas; but it has been remarked that when they reach the cliff, in the opposite direction, they cease to bear tin, and are wholly composed of iron. Here, too, they are in killas: in

short they have been productive of tin only in the growan. But what is very remarkable, a great portion of this rock consists of alternate courses of hard and soft growan, running in an east and west direction.

The following is the order in which, as far as I could collect from my informer, they succeed each other in a small part of the hill, which I examined.

1st. A large lode filled with loose growan.

2nd. A bar, as it is here called, of hard growan, running parallel with the lode on each side.

3rd. A small lode running on the outside of each of these bars.

4th. The common growan.

Advancing southwards from the last-mentioned, soft growan succeeds to the hard growan, and extends to a breadth of two hundred and fifty fathoms. This has been sunk through to the depth of sixty fathoms, without reaching the hard growan. It contains broken masses of hard growan of all sizes, and when the miners are driving north and south through this soft growan, they suddenly arrive at a solid wall of the hard growan, The hard courses vary from three to twelve feet in breadth. I found the breadth of one of the soft courses of growan to be five fathoms, and in a quarry near this spot, I observed the soft overlying the hard growan, and at the bottom of the soft growan, both rounded and angular fragments of the rock, of all sizes. The extent of the soft growan eastward from this point, towards the foot of the beacon, is about three hundred and fifty fathoms.

The very remarkable twin crystals of feltspar, which are so well known to collectors of minerals, are found in the soft growan, contiguous to the lodes here, and I received from the Captain of Huel Coates mine, a small collection of very perfect insulated crystals of quartz, which he had picked out of the soft growan.

The great lode, as it is here called, underlies three feet and half to the south. All the other lodes underlie to the north about one foot in a fathom. They abound in heaves and slides.

Under the black vegetable mould I observed six or eight feet of brown rubble-earth, filled with pebbles of quartz and peach-rock, more or less rounded, together with some fragments of growan. Intermixed with this rubble, they find tin both in the state of sand and gravel. They even find tin in the black mould above it. I also observed some marks of streaming excavations down to the surface of the hard rock. This alluvial deposit must be referred to the same epoch as that which produced the stream-tin, on the opposite side of the beacon.

I have thought it necessary to record all these particulars respecting this very insulated mass of granitical rock, because they collectively throw some light on its natural history. Its compound nature is so evident, that the miners here do not hesitate to call it a growan. On the other hand the mica, which is one constituent part of granite, is here almost wanting, and the insulated crystals of quartz, which are dispersed through the mass, give to it the

character of a porphyry; the question of its denomination, therefore, lies between the choice of the two terms porphyritical granite or granitical porphyry.

The same rock occurs again at Cliggar point, below the great St. George mine, and on the rise of the hill, close to the south lode of Wheal Leisure, although in masses of small extent. The specimens of the rock, which I procured from each of these places, are in a semi-indurated state, and of a light grey colour; and it is remarkable that all the killas at Wheal Leisure is in the same state of induration, and nearly white. Is it fair to conclude that this anonymous rock has such a geognostical affinity to these rich copper lodes, as may account for their existence here in a district so remote from the central granite?

Since the above was communicated to the society, I have received a specimen of true granite from Cliggar point. I am disposed, therefore, to consider all the growan of the beacon, as well as of Cliggar point and of Wheal Leisure, merely as modifications of granite, and not as varieties of elvan.

XI.—*On the Manipulations to which the Ores of Tin and Copper are subjected in the central mining district of Cornwall.*

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(Read October, 1828.)

THE mode of *dressing* the tin and copper-ores of Cornwall, or preparing them for being smelted, has been described by Borlase,* and more largely and minutely by Pryce;† but within the last fifty years considerable modifications and improvements have been introduced, and although the principle on which the operations are conducted is nearly the same, the mode of applying it is in many cases very different. It will also be perceived, on comparing the following observations with those of Dr. Boase,‡ that the practice in the central mining district of Cornwall varies considerably from that which prevails in the mines of St. Just and its vicinity.

* Nat. Hist. page 177. † Mineralogia, page 215.
‡ Vol. 2, page 386.

It should here be premised, that the tin-ores are in general carried, by the miner, through all the operations necessary for their purification previous to their being smelted. The smelter has, therefore, only to carry them twice through the furnace: by the first melting, they are brought into a metallic state; and by the second, the metal is sufficiently purified. The ores of copper, on the contrary, are only brought by the miner, into the state which makes them fit for roasting or calcining: in this state they are sold to the smelter, by whom they are alternately roasted and smelted several times, before any appearance of copper is visible; and after they are reduced to metal, it undergoes three purifying operations, before it is fit for the market. On this account, although a given quantity of average copper-ore, as it comes from the *lode*, is much richer and more valuable than an equal quantity of tin-ore in the same state; the tin-ore when prepared for sale, is at least seven times richer than that of copper.

TIN-ORES.

The first operation after the ore is raised from the mine, is to break into pieces about as large as a man's fist, any stones which may exceed that size; and to reject such portions of them, as do not contain more ore than will repay the cost of *dressing*. Although this appears a matter of little consequence, it is of importance to separate as much as possible of the refuse in the first place; as the loss of ore in

dressing is proportional to the quantity of refuse. The tin-ore, in some stones, is scarcely perceptible to the eye; in which case the workman, from time to time, reduces a small quantity to an almost impalpable powder, and by repeatedly immersing it in water, and shaking it to and fro on a shovel, the impurities are removed: by this simple operation, which is called *vanning*, the quality of the ore is roughly ascertained, as well as the size to which it must be reduced, in order to its being freed from foreign substances.

The ore is now ready for the stamping-mill. This machine consists of three or four upright wooden beams, called *stampers*, about ten feet long, and seven to eight inches square, to the lower extremities of which are attached pieces of cast iron; varying in weight from one hundred and half, to four hundred and quarter: these are placed in a wooden frame, and alternately lifted up about ten inches by the cogs or *wipers* of a horizontal axle, which is moved round either by a water wheel or a steam engine.* The ore is placed on an inclined plane close to the bottom of the *stampers*, and as these are lifted up, a portion of it slides down directly underneath them, and is crushed by their fall. The aperture through which it is admitted, is of such dimensions as to prevent the entrance of so much as would impede the action of the machine.

* The mills which have only three or four stampers are those which are worked by water wheels: by the application of steam, the number of stampers has been increased in many cases to twenty-four, and in some to thirty-six, and even forty-eight.

The second stamper is lifted an instant before the fall of the first, and the third before that of the second. The fall of the first forces a portion of the ore underneath the second, and that of the second underneath the third: the fall of the last forces such of the ore as has been sufficiently pulverized, through a grating* placed opposite the apperture by which the ore is admitted under the stamper: the holes of the grating vary in size, according to the nature of the ore, from the diameter of a reed to that of a small needle: the whole is copiously supplied with water, which aids the progress of the tin through the grating, and is in proportion to the size of the holes therein. Adjoining the stamping-mill, and connected with the grating by a conduit, are two pits: the ore after passing through the grating, runs into the nearest pit, in which the rough ore lodges, as well as the heavier part of what is reduced to powder, and known by the name of *slime:* this rough ore, when *dressed,* is called the CROP. The remainder, with the lighter *slime,* which passing through the first pit, is retained in the second, when dressed, is called the LEAVINGS, and varies in quantity from one-fourth to one-seventh of the whole. Now begins the process of purification, so far as to prepare the ore for being smelted; and this comprizes a surprizing number and variety of operations, but the great principle of the whole is that of subsidence by superior gravity.

* The grating should be made of copper where the water contains cupreous salts; but otherwise, of iron: whilst in some places, the grating is entirely dispensed with.

The Crop.

1. The first operation is ***Buddling***. The *buddle* is a wooden case about eight feet long, two and half to three feet wide, and two to two and half feet deep, fixed in the ground, one end of it being a little elevated: on the rim of the higher end is fixed a board from a foot to sixteen inches wide, extending from side to side, and somewhat more inclined than the *buddle*: it is termed the *jagging* board. The operator, who is usually a man or a stout boy, spreads the ore on the *jagging* board, and with his shovel cuts it into small furrows, parallel to the length of the *buddle*: a small current of water which is admitted at the head of the *buddle*, is made to run equally on every part of the board.* The action of the water carries all the ore into the case, where the richer and finer portions subside near the head; whilst the rougher and lighter portions are carried towards the lower part. The workman, who stands in the buddle about three feet from the head, assists the action by gently passing his foot along from side to side.† This process is continued until the buddle is filled. Its contents are then divided into three or four parts, according to the quality of the ore: these divisions are denominated ***heads, first middle***

* The water varies in quantity according to the roughness of the ore; that which is coarsest requiring about as much as a circular aperture of an inch and half in diameter would admit, but the finest, only about one-ninth of that quantity.

† When the ore is rough this operation is generally performed with the naked foot; but when the particles are very fine, the foot is usually shod with a smooth piece of wood,—the *brogue*.

heads, second middle heads, and *tails;** the *heads*, or richest part, being nearest the head of the buddle, and the *tails,* or worst part, being nearest the foot: each of these is again separately *buddled,* until the ore at the head of the *buddle* is freed from the poorer and rough particles.† They are then exposed to the following operations, viz. the *heads* are *tossed;* the *first middle heads* are *chimmed;*‡ the *second middle heads* are *dillued;* and the *tails,* if poor, are thrown amongst the *leavings.*§

2. *Tossing, Tozing,* or *Terloobing,* to which the *heads* are subjected, is performed in a *kieve,* or large tub, about one-third filled with water, which a workman stirs about rapidly, whilst another gently puts in the ore with a shovel; this is continued till the vessel is nearly full: the stirring is then stopped, and the outside of the kieve is smartly struck with a hammer until the ore has subsided: this is called *packing,* and in some cases a few minutes are sufficient for it, but in others it is necessarily continued for some hours, the time being longer as the ore is finer. By this process the most impure parts are

* When the ore is of low quality, the *tails* are at once thrown amongst the *leavings;* but otherwise they are again *buddled,* &c. When the ore is extremely poor, the *tails* occupy nearly three-fourths of the *buddle.*

† The *first middle head* of the second *buddling* is frequently put with the *head* of the first *buddling;* and the *second middle head* of the second mixed with the *first middle head* of the first; and the *tail* of the second with the *second middle head* of the first.

‡ The *first middle heads* are often *tossed* like the *heads,* instead of being *chimmed,* and the *second* are *chimmed* instead of being *dillued:* in fact the order of the operations is frequently altered, to meet the quality of the ore.

§ Otherwise they are again *buddled* and then *tyed,* and the rougher parts which remain are again *stamped* with a very small-holed grating: and all that is not reduced to *slime* is again *buddled, tossed,* &c.

brought to the top, whilst the remainder subsides in the order of gravity: once tossing is frequently insufficient, in which case the operation is once or twice repeated. The whole is now divided horizontally into two or more parts: the lowest division (unless it requires roasting or calcination in order to clear it as far as possible from the ores of iron, copper or zinc, which is generally the case) is considered fit for the smelting house. The upper divisions (when the whole is separated into three) are denominated *top* and *bottom skimpings* (skimmings): these are again *buddled* and *tossed:* after *buddling*, the *tails* are thrown amongst the *leavings;* and the *middle heads* are mixed with the *skimpings* of the *first middle heads;* after *tossing* the *skimpings* are put to the *leavings*,* and the ore in the lowest part of the *kieve*, is fit either for the smelting house or the burning house.†

3. *Chimming*, to which the *first middle heads* are subjected, is an operation which appears at first sight to differ scarcely at all from *tossing*. The *kieve* in which it is performed is inclined at an angle of about 45°. About two hundred weight of ore, with an equal weight of water, are put into it, and violently agitated by stirring until the whole of the ore is suspended; the stirring being stopped, the vessel is beaten on the outside, as in *tossing:* the water being withdrawn, the upper layers of ore (also called *skimpings*) are treated in the same way

* These are termed *skimpings of skimpings*, and are dressed on the *frame*.

† The house in which the roasting or calcining furnaces are erected.

as after *tossing:* the lower part is fit for the smelting house or the burning house. This mode, which is of comparatively recent adoption, is now generally practised in the Gwennap mines, in preference to *tossing*, both for *heads* and *middle heads*, especially when the impure parts of the ore are very heavy. It is evident that when a *kieve* is inclined, the space at the bottom is narrower, whilst the space near the surface of the water is larger, and the depth greater than if it were in a horizontal position, as in the operation of *tossing:* it is probable that the impure parts are thus more easily kept in suspension, and from the greater vibratory motion imparted by the hammering, in consequence of the *kieve* resting on a small and narrow base, the whole of the richest part probably subsides more speedily than it does in *tossing*.

4. *Dilluing*. To this operation the *second middle heads* are generally subjected. It is performed with a hair bottomed sieve of close texture, into which an assistant puts about thirty pounds of ore: the operator then immerses it in a kieve about two thirds full of water, and by moving it round, as well as up and down, and from side to side, in the water, the small and light particles become suspended, and by inclining the sieve, they pass out of it, and subside at the bottom of the *kieve:** the sieve is regularly

* The ore which subsides in the bottom of the *dilluing* vessel is called *flying*, or *dilluing smalls*, and is again *buddled* and *tossed*, or *chimmed* with the *middle heads* of the *skimpings:* the produce thus obtained is termed *round* or *leap* ore, and is of the most inferior description.

replenished from the ore-heap by the assistant, and the operation is continued: whether the ore in the sieve is now fit for the smelting house is ascertained by reducing some of the larger pieces to powder: if, on immersing this in water, the mixture is of a whitish colour, and if, on *vanning*, a little or no impurities remain, it is considered ready to be smelted; but if it be not sufficiently pure, the next operation, supposing it does not require to be *roasted*, is *tying*: but as the greatest part of the tin-ore of Cornwall needs *roasting*, this operation is the next part of the process.

5. *Roasting*. This of course cannot be included in the "manipulations" to which tin-ores are subjected; but it must not be passed over, or an important link will be wanting in the chain. It has been already observed, that if the tin-ore is much mixed with ores of copper, iron, or zinc, which cannot be got rid of by the common process of *dressing*, instead of being put at once into the smelting furnace, it must be previously *roasted*, or, as the miners term it, *burnt*. The furnace, in which this is done, is about nine feet long; its width is irregular, being about three feet where it adjoins the fire-place, five feet in the widest part of the middle, and a foot and half at the mouth; the height is about sixteen inches in the middle, and ten at the sides; the fire-place is about twelve inches in breadth, and is separated from the body of the furnace by a wall just high enough to keep the fuel separate from the ore. On looking in at the mouth, the flame of the

fire is seen proceeding from the fire-place through all the length of the furnace, and going up the chimney, which is situated close to the mouth. The furnace being raised to a dull red heat, about seven hundred weight of the ore is put into it, through a hole in the top: if it were roughly stirred at once, the rapid evaporation of the moisture, contained in it, would probably dissipate a portion of the ore: it is, therefore, allowed to remain unmoved for about an hour, in order to the gentle evaporation of the water: it is then spread over the furnace for about four feet in length, nearest the fire; and, by means of an iron rake, is turned every half-hour or oftener, that the whole may be equally exposed to the action of the fire. This continues* until it ceases to give out whitish fumes; or, when turned, to exhibit bright sparkles: it is then withdrawn through a hole now uncovered in the bottom of the furnace, and allowed to cool: it is then subjected to

6. *Sifting*. This is so common an operation, as scarcely to need a description:—after being sifted,†

* Sometimes, when the ore is only partially *roasted*, it is taken out of the furnace, and *sifted*, and *buddled*, and then *tossed*, *chimmed*, or *dillued*: then *roasted* a second time: in this way some ores are more easily cleansed from their impurities than if they had been wholly roasted at once. The ore in this half-roasted state is called *rag-burnt:* when it has been *buddled*, the *tails* are considered equal to the *middle-heads* of the ore which has not been roasted, and treated accordingly: being *tossed*, *chimmed*, or *dillued;* the *skimpings* of the tossed ore being again *buddled*, the *tails* are thrown by as *burnt leavings*, and as they frequently contain copper, they are sold as copper-ore, if the copper in them amounts to two and half per cent.

† When the tin-ores are mixed with those of copper, (generally sulphurets) the water in which they are sifted, after being roasted, holds the sulphate of copper in solution: sometimes the water is evaporated, and the salt allowed to crystallize, or else the copper is precipitated by the immersion of iron in the solution. According to Mr. Carne, (Vol. 2, page 336,) it has been found in

the ore is generally *tossed, buddled,* and again *tossed,* and is then ready for the smelter: but some kinds of ore require other operations after being roasted, as

7. *Tying*, which may be done either in the *buddle,* or in a *tye,* purposely constructed for the operation. The *tye* is a long, narrow, inclined furrow, through which passes a stream of water, three or four times larger than that used for *buddling* the ore: the ore being placed at the head, and agitated with a broom,* the rough and lighter particles are carried to the lower part of the *tye.* The ore at the head, unless it requires to be again *dillued,* is fit for the smelting house. The remainder, if very poor, is thrown amongst the leavings; but is otherwise exposed to another operation, called

8. *Jigging.* This is performed by plunging a copper-bottomed sieve, into which two or three shovels full of ore have been put, into a vessel of water: the operator, holding the sieve in his hands, gives it at the same time a vertical and rotatory motion, taking care that it be never lifted above the surface of the water: by this means, the different parts are arranged in the sieve in the order of gravity: the lighter portions being brought to the top, are removed, and considered as *leavings,* and a fresh supply of ore is thrown in and *jigged,* until the weight of the richer part at the bottom of the

Botallack, that one hundred pounds of iron induced the precipitation of one hundred and eighty pounds of copper. The cupreous salts are usually mixed with those of iron, and other metals, the separation of which is expensive, as well as difficult.

* When the *tails* of the *buddles* are *tyed*, the water is agitated with a shovel instead of a broom.

sieve becomes too great for the operator: it is then taken out and considered fit for smelting.

These, I believe, are all the operations to which the *crop* is subjected; but the order of their application is subject to variation, arising from the difference in the quality of the ore.

THE LEAVINGS.*

These comprise the whole of the *slime*, the *tails* of the *buddles*, the *skimpings* of the *skimpings*, and the *skimpings* of the *jigging*. The *slimes* and *tails* are subjected to

1. *Trunking*. Previous to this a large surface of the slime-ore is generally exposed to the air, in order that the moisture may evaporate: it is still better if it be thoroughly dried, as the alternations of dryness and moisture facilitate the separation of the soft and earthy substances.

The *trunk* consists of three divisions, viz. the *strèke*, the *còver*, and the *hutch*: the *strèke* is a furrow about five feet long, and two and half feet deep: at the higher end it is two and half feet wide; but it becomes gradually narrower, so that at the lower extremity it is only six inches: it is walled on each side. The *còver*, which is situated at the lower end of the *strèke* is a box of about three cubic feet in capacity. The *hutch*, which is separated from the *còver* only by a single plank, is a wooden case about

* Sometimes the proprietor of the ore bargains with the *dresser* that the *leavings* shall be taken by the latter, at a certain proportion of the value of the *crop*: in this case he is restricted, in *dressing* the *crop*, to the use of the *buddle*, *kieve*, and *sieve*.

eight feet long, two and half to three feet wide, and about a foot in depth: its bottom, as well as that of the *strèke*, is a little inclined. The slime being put into the *strèke*, a stream of water, as large as a circular aperture of three-eights of an inch in diameter will admit, runs over it, and being occasionally agitated, a portion of the slime is suspended by the water, and is thereby carried into the *còver*: great care must be taken that too much slime be not held in suspension at once: the best proportion is about one-sixth, or one-eighth of the weight of the water. The operator* (usually a child) with a shovel agitates the water in the *còver*, and occasions its rippling over the dividing plank into the *hutch*: the quantity passing over at once is very minute; but the ripples rapidly succeed each other: by this means the best parts of the slime remain at or near the head of the *hutch*, while the poorer parts are carried off by the water.† This operation is continued until the *hutch* is full:‡ the contents are then removed to go through another operation, called

2. *Framing* or *Racking*. The *frame* is a flat piece of wood, about eight feet long, and five feet wide, with a rim, five inches high, around it: this is suspended in an inclined position on pivots, but is

* *Trunking* is now in many places accomplished by machinery.

† These are termed *loobs*, and are sometimes worth a second operation; but this is not often the case, if the first has been carefully conducted: this may be judged of by the motion of the liquid in the *còver*, which should have an equal velocity at the middle and sides.

‡ There is probably more ore lost in *trunking* than in any other operation. It has been said that many persons formerly gained a subsistence by gathering the ore which, having been carried down from the Gwennap mines, had subsided in the Carnon vale, between high and low water mark.

fastened by a kind of latch: at the upper end is a *jagging* board (similar to that of the *buddle)* which is connected with a *frame* by a moveable sloping piece of wood to prevent the ore from falling between the board and the *frame:* underneath the *frame* are two boxes, which, being placed end to end, extend its whole length: at the lower end of the floor a vacancy of two or three inches, leaves an aperture for the escape of the water. The mode of conducting this operation is as follows. The operator (usually a woman, or stout boy or girl) spreads on the *jagging* board from two to three quarts of the *trunked slime,* on which runs a stream of water, equal to five-eighths of an inch in diameter; and, with a small toothless rake, makes in it small furrows in the direction in which the water runs: in this way the ore is carried from the board to the *frame:* the richest part rests at and near the head, and the poorer parts further down: the impurities are carried off by the water and escape at the bottom. The operator runs the rake across the *frame* to agitate the ore, as often as appears requisite.* When the richer part of the ore has sufficiently accumulated, the *jagging* board being swept clean, the latch is lifted, and the *frame* turned on the pivots from a horizontal to a vertical position, and the ore is swept or washed into the boxes beneath: the best into the upper, and the inferior into the lower box. It is of the greatest importance that the water should pass of equal depth and velocity over every part of the *frame,* or the

* This should be as seldom as possible;—the reason is obvious.

different parts of the mass will be mixed with each other, and some of the ore carried off with the waste. If the ore deposited in the upper box be contaminated with the ores of copper, iron, or zinc, it is *roasted,* and afterwards treated the same as that which has *not* been burnt: viz. it is *sifted* and *tossed:* the lower part of the contents of the *tossing kieve* is *buddled* and again *tossed,* and is then fit for the smelting house: the upper part is again *framed* with a smaller stream of water. The ore deposited in the lower box, beneath the *frame,* may be again *framed* with a fresh proportion of *trunked* ore; but it is not unusual to *toss* it, and *buddle* the richer contents of the *tossing kieve:* the ore at the head of the *buddle,* if not needing a repetition of the process, is *tossed;* and is then fit for the smelting house: the remainder is again *trunked,* &c.

Although these are in general all the manipulations to which tin-ore is subjected from the mine to the smelting house, it is often necessary to expose it to a far greater repetition of them than it is possible to describe, as well as to vary the order of their application. It is remarkable, however, that very little improvement has been made in the mode of *dressing* tin-ores for nearly a century.

Copper-Ores

When brought to the surface of the mine, are divided into three parts;* the first, consisting of

* If, when brought to the surface, the ores are mixed with clay, they are first washed in a *strèke.* This is done by stirring them with a shovel, in a stream passing over an inclined plane.

pieces above the size of a fist, denominated *spalling stuff;** the second, of such smaller pieces as will not pass through a sieve, of which the holes are three quarters of an inch square, (called a three quarter inch *griddle)* which is termed *picking rough;* and the third, of all that passes through the sieve, denominated *shaft small.*

The larger pieces being broken to about one inch and half square, are mixed with the *picking rough,*† and the whole divided into

1st. *Prills,* or lumps of pure ore.

2nd. *Dradge,* or ore mixed with other substances.

3rd. *Halvans, hennaways,* or *leavings,* which contain but a small quantity of ore.

The *prills* are *bucked:* an operation which consists in breaking them into pieces of about half an inch square,‡ and is performed principally by females, with large flat-polled, two-handed hammers; this portion of the ore is then ready for the market.

The *dradge,* when containing but little iron pyrites, is *bucked* to a still smaller size than the *prills;* and then *jigged*§ in a sieve of about five holes in the square inch. By this means it is separated into four parts.

1st. That which passes through the sieve, and is usually fit for sale.‖ This is denominated *hutch-work.*

* The *spalling stuff* is more readily separable from the *shaft small* by hand, than with the *griddle.*

† The *spalling stuff,* and *picking rough,* are now mixed.

‡ In most of the large mines this is now done by machinery.

§ Copper-ore has of late been frequently *jigged* by machinery; but I am not aware of tin-ore having been yet so treated.

‖ When the first *jigging* is insufficient, the operation is repeated in a smaller holed sieve.

2nd. The portion occupying the bottom of the sieve, which is in a marketable state, and is called *ragging*.

3rd. The middle part of the contents of the sieve; which is again *bucked* and *jigged*.

4th. That at the top of the sieve; which is put among the *halvans*.

But if the *dradge* contain much iron-pyrites, *jigging* will not separate them; they must, therefore, be *cobbed*, and *picked*. This is usually done by females and children; the pieces being broken to about five-eighths of an inch square, and the impurities picked out by hand.

The *shaft small* is *jigged* in a sieve of four or five holes in a square-inch. That which passes through *(hutch-work)* is usually ready for sale; but when not so, it is *tyed;* the head of the *tye* being sufficiently pure; the *tails* are either considered *halvans*, or are *jigged* in a small holed copper-bottomed sieve.*

That portion of the *shaft small* which rests in the bottom of the sieve, and what passes through it, are now saleable. The middle layer of the contents of the sieve, called *toppings*, is again *bucked* and *jigged*. The upper portion being *halvans*.

Some of the ores of copper are so soft, that exposure to water would occasion loss: in which case they are fit for the market, after being *sifted, cobbed*, and *picked*.

* The sieve used in the first *jigging* is sometimes employed: a layer, about one inch in depth, of pieces of iron-pyrites, about five eighths of an inch square, being placed in the bottom thereof.

The *halvans, hennaways,* or *leavings,* are the refuse from the preparation of the *crop;* and when not much mixed with iron-pyrites, those portions which contain the greatest quantity of ore, are *bucked* and *jigged.* But when mixed with foreign substances of great specific gravity, they are *cobbed* and *picked.* The portions which contain but little ore, are *stamped;** and the *stamped* work is *trunked.* The *larger* particles of the *trunked* ore are *tyed.*

The finer portion, with the slime from the first washing,† and the *tail* of the *stamps* pit, are *trunked* and *buddled.* The small portions remaining in the *tails* of the *tyes* may be obtained by *jigging,* in a fine copper-bottomed sieve. The operations being repeated, until the whole be deemed ready for the market.

Tin-ore sometimes occurs in the heads of the *tyes* and *buddles;* when the quantity thereof is sufficient to render it worth extraction, the whole is roasted and *dressed* as tin-ore. The copper-ore being in some quantity converted into soluble salt by the roasting; and the remainder, now denominated *burnt leavings,* is treated as before described.

I am disposed to claim for this communication, some practical utility; which, however, belongs to the late Capt. Thomas Garland, of Illogan, Mr. John Rowse, of Perran-arworthal, and Jeremiah Mellet, (a working miner of very great experience)

* Water should be copiously supplied; but if permitted to exceed a certain depth, it impedes the operation.

† See note (*) page 159.

residing at the latter place. My own portion of it being merely to collect the results of their experience; whilst I am indebted to the kindness of Mr. Carne, for arranging them in their present form.

SUPPLEMENTARY REMARKS.

(February, 1832.)

SINCE the preceding pages were communicated to the society, some improvement in various parts of the operations have been introduced.

1. *Toxing* has been performed by a machine, first introduced at Ball-dhu, by Mr. Bell, of Northumberland.* The apparatus consists simply of an arm or wing, extending from a vertical axle, which is temporally placed in the centre of the kieve; to which a rotatory motion is imparted by the hand. I am disposed to think this machine, which is not at present much used, might be advantageously employed.

2. *Trunking* by machinery is now very common; so far as I have been able to learn, it was first introduced in the neighbourhood of St. Ives, about seven years since. This machine consists of a horizontal axle, into which are fixed small spatulas; sometimes made of iron. These spatulas are introduced into the *cover*, and motion to and fro communicated to

* Forster, Section of the Strata from Newcastle to Cross Fell, page 362.

the axle in which they are fixed, either by hand, or by connecting it to some machinery.

I believe in this, and the further treatment of *slimes*, we are much behind the German *dressers*. Their *frame* is often thirty feet in length; and is so combined as to receive a gentle horizontal motion which is given by machinery, and is thought to be very useful in separating the ores from the waste. It appears to me very probable, that the introduction of something of this description,—which would doubtless, require some modifications, to meet the various descriptions of our ores,—would be very advantageous; and might possibly merge the operations of *trunking* and *framing* into one.

3. *Bucking*, is now in most of our large mines, superseded by the the introduction of crushing machines. These consist of a pair* of iron rollers, moved by machinery; between which the ore is introduced, the distance between them being regulated by the size to which the ore is to be broken. A sieve is attached to the machine, by which the ore is sifted immediately as it proceeds from between the rollers. Crushing machines were introduced by Mr. John Taylor, at some mines under his management, near Tavistock, about twenty years since. I believe they were, in Cornwall, first used at Lanescot mine; and they have been subsequently introduced at Binner Downs, United Hills, Huel Towan, Consols, and many other mines.†

* I have seen three pairs of rollers in the Crushing Machine at Lanescot.

† At Huel Charles in St. Agnes, a *stamping mill* is used for the purpose; but without the presence of water.

4. *Jigging* by machinery, has long been common in the north of England;* and was first accomplished in Cornwall by Mr. Bell. His apparatus (the *brake-sieve)* consisted of a rectangular sieve, about four or four feet and half long, by one and half or two feet wide; it was attached to one end of a lever, and motion communicated by a child placed at the other. Within a very short time, Mr. Richard Taylor has had several of these constructed at the Consolidated and Pembroke mines; these are set in motion by water-power.

Mr. Petherick has recently obtained a patent for a most ingenious machine for the same purpose. In this the sieves are at rest, whilst their contents are agitated by the variable height of the water in which they are immersed.*

* Quarterly Mining Review, Vol. 2. page 256.

XII.—*Contributions towards a knowledge of the Geology of Cornwall.*

By HENRY S. BOASE, M. D.

(Read October, 1830 and 1831.)

One of the primary objects, contemplated by the founders of this Society, was to ascertain the nature and boundaries of the Cornish rocks; in order, that their geographical relations might be accurately delineated on a Map.

Several illustrations of this kind are, indeed, already before the public; but they are deficient in those minute details which a Map, proceeding from this Society, might be expected to supply. Towards the accomplishment, however, of this important work, so often promised, comparatively little has been hitherto effected; and, even since that little was done, several years have passed away.

Whilst I had the honor of being one of the officers of the Society, I strove to redeem this pledge: but circumstances of a private nature prevented me then from taking such an active part in this work, as I desired. The time, however, at last came, when

I had it in my power to follow my inclinations; and I have accordingly devoted the two past years almost entirely to this object: during which period I may, without presumption, say that I have patiently and zealously laboured in the cause; having performed more than twelve hundred miles *on foot,* visiting every part of the county, and sparing neither personal toil or expense, in endeavouring to gain a more perfect knowledge of the geology of Cornwall, than could be obtained by strangers, however well qualified for the task, in their hasty and partial excursions.

In mentioning these circumstances, I do so merely with the view of shewing, that the following details have claims on your attention, as the results of actual observations, on a country which affords, both in natural and artificial sections, more ample opportunities for studying the nature of primary rocks, than any other portion of the globe.

The plan that I propose to adopt in treating of this subject is, in the first place, to record the various phenomena as they present themselves in detail, whilst traversing the country; avoiding, as much as possible, any theoretical observations thereon:—and, in the next place, to arrange the rocks in geological order; and to discuss the various theoretical subjects suggested by the facts previously recorded.

It has occurred to me, that the first part may be considered, by some, a series of long and tedious repetitions: but having weighed this objection, I cannot, for the sake of rendering this communication

more palatable to the general reader, consent to curtail or omit that which is the ground-work of the whole; and which, although its materials are rude, and its construction rough and unsightly, may nevertheless furnish a good foundation for a more finished superstructure.

These details might, indeed, have been less voluminous, if I could have been contented to call the schistose rocks by the names of greywacké, clay-slate, and others equally inapplicable: but in this case I should have failed in the principal object of my labours,—viz. the attainment of a more perfect knowledge of the Cornish rocks. Finding, therefore, that the present nomenclature would not enable me to convey a correct idea of all these rocks, I determined on giving, whenever needful, a short description of each rock, in preference to the use of terms so indefinite; and, in order to guard still farther against mistakes, I have annexed numbers thereto, referring to the specimens of the rocks themselves, which are deposited in the Museum.

On taking a general view of Cornwall, it will be found to contain several insulated groups of granite; four of which are of considerable size, and nearly equidistant from each other. These groups with their respective, subordinate, and surrounding rocks, may be regarded as so many *districts;* into which, for the sake of facilitating description, the County may be divided: and they may be called—the western or Land's End District,—the Carnbrea District,—the Central District,—and the Eastern District.

Not that these divisions are to be found in Nature: for although the granite groups are distinct, no boundaries can be detected between the schistose rocks of adjoining districts: nor is there any reason to believe that such exist. Adopting, therefore, these divisions only on account of their convenience, it is proposed to arrange the first part of this communication under these four heads.

CHAP. I.

ON THE GEOLOGY OF THE EASTERN DISTRICT OF CORNWALL.

The portion of Cornwall about to be described under the title of the Eastern District, includes the Hundreds of Stratton, Lesnewth, Trigg, East, and West, and also the parishes of North Petherwin and Werrington, which indeed belong to Devon, but are situated on the Cornish side of the Tamar; and in a geological point of view, may be regarded as belonging to Cornwall:—or, the Eastern District may be defined as that part of Cornwall, which is bounded by the Tamar on the east;—by a line drawn between Lostwithiel and Wadebridge, connecting Fowey and Padstow Harbours, on the west; —and by the sea, on the north, and on the south.

On referring to the annexed coloured map, it will be observed, that besides the large central patch of granite, there is another smaller one near Callington, on the eastern boundary of this district; and, as it is of no great extent, it may be considered as subordinate to the main mass, the same as that of St. Michael's Mount in the western part of the county. And it may be here understood that in the following details, whenever the granite of a district is referred to, the central mass is meant, unless otherwise specified.

The granite of the eastern district is ten miles in length, and six or seven miles in breadth at the widest part. It forms the most elevated land in the county; but it is inferior to the Dartmouth range, its highest hill, Brown-Willy, not exceeding 1,368 feet in height, according to Mudge's survey.

Throughout its whole extent it is one expanded scene of sterility and desolation: trees there are none; and it is only in favoured spots, that vegetation has attained even to the size of a furze-bush. The elevated situation of this granitic land, exposed to every blast from the ocean, is, without doubt, unpropitious to the growth of trees and shrubs: but this is not the only cause, a more powerful one is to be found in the mineralogical composition of the granite, and in the nature of the mass that results from the decomposition of this rock. The grains of quartz render the granitic soil gravelly and easily permeable to water; so that, in all inclined situations, the rain washes away the fine particles of

light clay that have been produced by the decay of the felspar: thus rendering the soil less adapted for vegetation, and not sufficiently tenacious to give a firm support to trees.

The general appearance, however, of this desert is not altogether uninteresting. All the hills are crowned, and covered on their precipitous sides, with immense hoary blocks of granite, which are generally heaped upon each other in the most fantastic forms. That of the *Cheese Wring* is one of the most curious of these Tors: but this, as well as the rock-basins, and the various semblances of castellated ruins, so common on the granitic hills of Cornwall, have been so often described, and so frequently visited, that, to enumerate them again in this place, would be a needless repetition.

Another general feature of this granitic district deserves more particular mention. The bottom of all the valleys are covered with bogs, which are sometimes so extensive and deep, and have such long and winding branches, that it is difficult, even in fine weather, for a stranger to extricate himself, when once entangled in their mazes. In many places, the bog is more than a dozen feet in depth: the bottom layers of which being consolidated by the superincumbent weight, afford a good peat, not inferior to that of Ireland. The plants that form these bogs, and their peculiar mode of vegetation, are generally known: but I noticed one circumstance here, which may not have escaped the observations of others, but which I do not remember to have

seen recorded;—viz. that the rain-water which collects in these marshes is more or less turbid from the presence of fine aluminous particles derived from the disintegrated surface of the granite rocks. Now it follows, that this earth slowly deposited amongst the roots of the aquatic plants, will serve to elevate the bottom of the marsh, and hasten the accumulation of peat by increasing the pressure: and will also explain the uniform intermixture of earthy particles throughout both peat and coal.

The granite of this range is well characterized by that of Brown-Willey, (No. 1.) which is composed of white crystalline felspar, grey quartz, and two kinds of mica; one of which is white and transparent, with a silvery lustre; the other of a dark garnet colour, and nearly opaque: a black mineral, like shorl, is also occasionally disseminated throughout the mass in minute prisms, or crystalline grains. The granite of Brey Hill (2.) is of a similar kind.

This granite is not very prone to decay, owing to its constituents being in large crystalline concretions: the outer part of the blocks only are effected by the elements, as may be seen in No. 2, from the summit of Rough-Tor. Here in this granite, occur layers of a fine-grained rock (4.) which is composed of the same minerals, differing only in the mode of aggregation. This occurrence will be hereafter noticed in other parts of the district: and this, together with the coarse-grained which sometimes also contain porphyritic crystals of felspar, form almost the only varieties that came under my observation. It

is probable, however, that this may be owing to the few opportunities that occur in this part of the county of obtaining an insight into the interior: for the granite of the western district, in our vicinity, affords great varieties, although the main mass of this rock is exactly similar to the one under consideration; but then its numerous sections made by the sea, and by mining, are fully proportionate to this superiority.

In the following details it is proposed to commence at the granite, and thence, as from a common centre, to traverse each district by various tracts; so that the rocks, wherever they present themselves, may be examined in their natural order of succession.

From Rough-Tor to Crackington Cove.

Proceeding due north from Rough-Tor, and crossing Crowder Marsh, an extensive barren tract succeeds, known by the name of Davidstow Moor. Numerous quartz pebbles of a milk white colour (5.) are scattered over its surface: and detached masses of rock only occur, which (6.) is a fine-grained granitic rock composed of a basis of compact felspar, including grains of quartz and mica with imbedded crystals of white felspar. It, therefore, resembles the granitic *elvans;* and such a course may probably traverse this moor, which is, I think, without the boundary of the granite; but no opportunity offered here of observing the junction of this rock with the slate.

The common, northward of Davidstow *Church-town,** is covered with large blocks of stone, which have the outward appearance of masses of granite: but, on examination, they are found to be a compound (7, 8.) of granular felspar, and crystalline hornblende; the former of these minerals predominates, so that this rock might be considered as a variety of sienite. It possesses, in a high degree, the characteristic toughness of hornblende rocks: and it does not appear to be very prone to decomposition, as the weathering of these blocks does not extend many inches beneath the surface. On these accounts it is well adapted for building: at present however, it is seldom employed for this purpose; but it may be frequently seen in the walls of the neighbouring churches, particularly in those parts of these edifices that require the material to be strong and durable.

Some of these blocks of hornblende-rock are detached, but the greater part are in *situ;* being the outgoings of the stratum, which, however, is not sufficiently exposed to shew its extent and bearings.

Inclining a little to the westward of Davidstow, on the road to Hendraburnick, a slaty rock, (dipping N. E., at an angle of 20°.) presents itself in a road-quarry, near the stone post which marks the

* In Cornwall the churches are generally called after the parishes in which they are situated; and the houses around them, be they ever so few, are distinguished by the name of the *Church-town:* but in the following pages, the words *church-town* will be omitted, and the place will be simply denoted by the name of the parish. This, I am aware, is not correct; but as the parishes (the boundaries of which are not easily ascertained) will be seldom alluded to, no confusion can arise after this explanation.

boundaries of the parishes of Minster and Davidstow.

This slate (9, 10.) is of a bluish grey colour; and when viewed, in certain positions, it has a speckled appearance, arising from minute grains of a dark coloured mineral which, under the magnifying glass, look like hornblende: so that it is probable, that this slate is a fine-grained mixture of the same minerals, which constitute the massive rock of Davidstow.

Advancing still northward, the next rock that occurs, is of a very interesting nature. It is composed of a bright bottle-green crystalline mineral, striated and somewhat scaly, resembling hornblende, (an intermediate substance perhaps between hornblende and chlorite) and of white calcareous spar: these minerals sometimes form alternate layers; at other times, are arranged in distinct granules; but more commonly are both intimately blended together, forming a compact mass traversed by numerous veins of calcareous spar. This rock (11, 12, 13, 14.) is met with in the valley just below the farm-house of Grylls, where the rivulet crosses the road; and is marked on the ordnance Map, as the Lime Kiln. A company of adventurers erected this kiln a few years ago; in hopes of obtaining lime for agricultural purposes: but as might have been expected, from the presence of hornblende, the whole charge of the kiln was fused into a mass of slag. This was afterwards obviated, for some time, by carefully selecting the veins of calcareous spar: but a similar accident again occurred; and the kiln remains, to this day, fully charged.

This bed of *hornblendic limestone* dips N. E., at an angle of 25°.: and at Grylls a slate overlies it, cropping out on the side of the hill, and having the same dip and bearings. This slate (15.) is more argillaceous, and of a finer texture than No. 9; but, in other respects, they are very similar.

Adjoining Lesnewth church, the slate (16.) is of a dark blue colour, and is traversed by numerous veins of quartz: it is glossy, and in the fracture exhibits a fine and uniform texture. A similar rock (17.) occurs in the valley south of St. Juliot; it is, however, softer than the last, striated and, being more free from quartz veins, is perhaps less siliceous.

Between St. Juliot and Minster, the slate (18.) is distinctly granular, consisting of white and dark coloured grains, probably of felspar and hornblende: and it is (19.) more hard and compact adjoining the large quartz veins, by which it is traversed. These strata also dip N. E., but at a greater angle than the preceding;—viz. at an angle of 30°.

On Tresparrell or Tresparrett Downs, a rock not unlike the last, is frequently exposed to view: it, however, contains much iron-pyrites which occasions a rapid decomposition, and renders it difficult to obtain a perfect specimen. On breaking down a considerable quantity of this decayed rock, (20.) numerous nodules (21.) are found, which are hard and unchanged. These nodules abound on the road crossing the downs; and they have so much the appearance of water-worn pebbles, that one naturally concludes, on seeing them, that they were brought

from the sea-shore which is not far distant: this fact affords another example of globular concretions having derived their form, not from the action of running water, but from the peculiar structure of the rocks. It may be remarked, that the iron-pyrites in these nodules, is generally in a more aggregated state than in the other parts of the rock; and might, therefore, have been expected to have experienced the same decomposition. This apparent anomaly may, perhaps, be accounted for, on the grounds of the different condition of the pyrites in the rock and the nodules:—in the one case, it is disseminated in minute particles; whereas in the other, it is collected into distinct crystalline concretions in the centre of the nodules, the substance of which being freed from this adventitious mineral is not so liable to decay:—and thus the imbedded pyrites is preserved from the action of the elements.

On the western side of Tresparrett Downs, near the farm of Hallimore, a slaty rock (22.) projects from under the soil on the road-side; it is easy to separate fragments of it a foot in length, and two or three inches in thickness; but the rock has undergone so great a change, that on attempting to break off a specimen, it shivers into thin flakes, and falls down like a pack of cards. Near the quartz veins this rock (23.) is more compact.

A little farther on, at Tregovel, the rock (24.) is similar to the last.

As you descend into Crackington Cove, the rock-scenery which suddenly breaks on the view, is

very grand. On the right hand, the cliffs are perpendicular, exhibiting a cross section of the strata; but on the left, they slope down to the beach at an angle of 40°. producing inclined planes of a hundred to a hundred and fifty feet in length.

The upper part of the cove is covered with fine shelly sand which is common to all the inlets of the sea on this coast, and which is carried away in large quantities, as a manure. Below this sand is an extensive beach of rounded pebbles; and beyond this, long parallel ridges of rock extend into the sea, in a curved direction, having the same bearings as the cliff on the left side of the cove. These inclined ridges are formed of a very hard massive rock (25.) which is sometimes (26.) traversed in every direction by innumerable quartz veins, varying from three inches to a line in thickness.

Between these ridges the rock (27.) is slaty, of a dark blue colour, and contains a large portion of iron-pyrites; in consequence of which, it decays and is removed by the action of the waves; whereby the more durable strata adjoining become prominent.

These two kinds of rocks are the only ones which occur in the cove; where they alternate with each other more than fifty times: and it is possible, that they form a continuation of those, already noticed, on Tresparrett Downs; for in this cove nodules (28.) are also distinctly seen imbedded in the slaty rock, No. 27, in such a manner as puts their nature beyond question. Several of the inclined strata on the left of the cove have their entire surface covered with

projecting nodules, giving them a blistered appearance, not unlike that of the hæmatites. This rock might, by some persons, be called a variety of conglomerate; but it differs very materially from this fragmentary rock, for both the nodules, and the basis in which they are imbedded, are composed of the same mineral substance.

Such are the rocks which lie between Rough-Tor and the sea-shore, in the parish of St. Gennys. Several general remarks might have been made on their nature, position, and conformation; but this will be deferred for the present, in order to avoid repetition.

From Rough-Tor to Tintagell.

On starting again from Rough-Tor and Brown-Willy, as from a centre, the granite is found to extend as far as Moor Gate, on the road to Camelford: but the junction with the slate is not visible, although it is here indicated by the improvement of the soil. A little farther on, near Pencarrow, hornblende slate (29.) makes its appearance: the specimen is somewhat changed by the action of the air, a better, however, could not be obtained, as only a small portion of the rock projects by the roadside. The neighbouring hills are steep, and are covered with cairns or tors, the rock of which (30.) is similar to the last, consisting of an intimate union of compact felspar and hornblende. In the valley adjoining Pencarrow, near a little stream, the side

of a vein or cross course of granitic *elvan* (31.) is exposed; but not sufficiently to shew its breadth or bearings. This rock also is much decomposed; it resembles, in composition, that of No. 6.

At Tremagenna (to the westward of the last place, and on the other side of the Camel, near the tenth mile-stone from Bodmin,) another *elvan* occurs, which has been extensively excavated for mending the roads, for which purpose it affords an excellent material. It is (32.) a white rock, composed of compact felspar, in which are imbedded limpid grains of quartz and scales of mica; it (33.) is also in some parts stained with rust-coloured spots, produced by the decomposition of some adventitious mineral, probably of hornblende: small irregular crystals of felspar may likewise be observed here and there, but they are of rare occurrence. As these workings are confined to the middle of the bed, on account of this part furnishing the hardest stone, no other kind of rock is brought into view; so that its geological relations to the adjoining strata are obscure. At present the excavation is several times as long as it is broad, and appears to be in the direction of this *course* of *elvan*, which in this case lies N. E. and S. W., parallel with the nearest strata of slate, which dip to the N. W., at an angle varying from 15°. to 20°.

About two miles north of Camelford, just above Slaughter Bridge (where tradition says that King Arthur fell in battle) is a bed of compact hornblende rock (34.) the same as No. 30: it is imbedded in a

slate, (35.) which is glossy and more argillaceous than any yet noticed. It has the same bearings, as that last mentioned.

To the westward of this place, on the side of the hill near Penpethy, occurs a more compact light-coloured slate, (36.) harder and less argillaceous than the last: it is full of small well-defined ochreous specks, the remains of imbedded particles of iron-pyrites.

A little farther north, near Trewarnet, is a large slate-quarry, called North Delabole, on account of the slate being similar to that of Delabole, which is about two miles distant, and has been long noted for the excellent quality of its slates. The North Delabole quarry is a very large excavation; and its machinery is well constructed: by one powerful water-wheel the water is pumped out, the slate and rubbish drawn up over a tram-road, and the large slates sawn into proper dimensions. The immense quantity of *overburden,* (i. e. the disintegrated rock and diluvium) to be removed, before the bed of good roofing slate can be quarried, must, however, be a great drawback on the profits of this undertaking.

One would think that this expensive operation might be avoided by mining, instead of quarrying, as is done at some of the slate-works in France. This obvious suggestion had also occurred to the proprietors, who at one time were desirous, as they informed me, of carrying it into effect; but, the quarry-men, whether from prejudice or well-grounded fears, felt so assured that the experiment would

be dangerous, that this project was abandoned. The objection of the men to mining was founded on the structure of the rock; and the state of the case appears to be as follows.

This quarry was originally worked without any system; that is, the *overburden* being first removed, wherever the good slate could be come at, the layers were forced up in any direction: experience, however, at last taught them that in one direction it was not only easier to raise the slate, but that the easiest way was attended with least waste; and in consequence the rock has been excavated into parallel *walls*, as the workmen term it.

These walls are produced by the *seams* or *joints* which traverse the strata at a considerable angle with the plane of inclination; a structure which is common to all the schistose rocks of Cornwall. Now, as these seams extend upwards through both the roofing slate, and that refuse slate which is superimposed, and as the former to be worked with advantage must be excavated from joint to joint, the workmen were of opinion that, if this were done, on the plan of mining, the upper part of the rock would be forced down by the incumbent pressure, and slide into the cavity beneath. As the object of this Society is not only to attain a mineralogical and geological knowledge of Cornwall, but also to improve the arts connected with the mineral kingdom, this subject is worthy of the attention of those members, who are more conversant, than I am, with the art of mining.

The rock at the upper part of this quarry, is similar to that of No. 36; the one last described as occurring at Penpethy. The roofing slate (37, and 38.) is of a dark blue, fine-grained and uniform in its texture; it is glossy, and when viewed by reflected light, appears to be covered with very minute spangles. It is translucent on the edges, or when divided into very thin laminæ. To which property must be attributed the peculiar mottled aspect of its surface when cloven; the numerous thin abraded laminæ on the surface, allowing the transmission of light, appear whitish, whilst the mass of the slate is blue and opaque. The slate is raised from the quarry in pieces of from eight to twelve feet long, and five or six feet wide, and about six inches in thickness, by means of eight or ten flat wedges, which are struck alternately by a like number of workmen. It would, however, be superfluous to give an account of the cutting and trimming the slates for the market, as these operations are the same as followed in Wales and other places, and which are generally well known.

Throughout the whole of the quarry there are insulated patches, which are not regularly foliated; but which (39.) break into thick coarse fragments with a conchoidal fracture. These patches are not homogeneous; in one part, they resemble the roofing slate; but in others, they contain a considerable portion of a dark green, foliated hornblende, (precisely similar to that which has been already noticed as occurring in conjunction with calcareous

spar in the rock at Grylls,) and a mineral in the form of white streaks which may be seen on a close examination, between the laminæ of the hornblende, and which on being tested proved to be carbonate of lime.

This fact is very interesting, for it seems to point out that this slate is connected with, or at least forms a member of, the same series of rocks to which the calcareous rock of Grylls belongs.

In this quarry there also occur contemporaneous veins of quartz, containing here and there clusters of rock-crystals of perfect transparency, and beautifully defined. To the workmen, however, who labour by *tut-work*, these quartz veins, although they obtain sometimes very great prices for these crystals, are unwelcome: for the slate in their immediate vicinity is of an inferior quality. From this circumstance it would appear, that the component parts of the slate are, adjoining the veins, differently combined: and in the veins themselves, these often form an assemblage of several simple minerals. In one of these veins (40.) occur pure white quartz, (both compact and crystallized) hornblende, flesh-coloured felspar, and calcareous spar; and the piece of rock attached shews how much it differs from the roofing slate, in which it was imbedded.

Proceeding northward, about midway between Trewithen and Trevenna, the slate (41.) is of a much darker colour than the last; but it has similar spangles which are large enough to be detached in the form of shining scales, but still so small that their nature is not apparent.

North of Trevenna, on the left-hand side of the road leading to King Arthur's Castle, is a small quarry, where the strata, as in the preceding, dip to the N. W., at an angle of about 20°. This rock (42.) is of a slaty structure, and in every respect resembles that of Penpethy, No. 36. A little farther on the same road, at Borough Mill, the slate (43, 44.) contains a larger portion of hornblende, and thin parallel layers of quartz, which (45.) is accompanied with green talc and carbonate of lime. On each side of the mill-stream there are detached blocks of a massive rock, (46,47.) commonly known in the neighbourhood by the names of *freestone and bastard granite:* it consists of granular felspar and shining lamellar hornblende, and is similar to the rock at Davidstow; but these specimens are not so perfect, owing to their having been broken off from the *weathered* part of the rock, whereas those from Davidstow were obtained from the inner part of a block that had just been cloven. This massive rock is very abundant in the hills on each side of the valley; and extends to the promontory on which Arthur's castle is situated; on the northern extremity, however, it becomes schistose, (48.) and gradually passes into an uniform greyish slate (49.) like those of Grylls and Penpethy. These rocks all dip N.W., at an angle of about 25°.

Having again crossed the strata intervening between the granite and the sea; it is next proposed to proceed along the coast to Tresparrett Downs, near which place the first section was completed.

FROM TINTAGELL TO TRESPARRETT DOWNS.

At Bossiney, the slate (50.) only differs from the last in being of a lighter colour, and rather more glossy. In Bossiney Cove* the same kind of rock occurs, some layers of which (51.) have a strong lustre: it appears to be a kind of talcose schist.

At Longbridge, between Bossiney and Trethevy, the slate (52.) is of a bluer colour, and more fissile. About two miles up the valley from the bridge, the stream falls over a projecting ridge of rocks, forming a cascade of about thirty feet in height. This is the celebrated Nathan's or Knighton's Kieve, which by our Cornish tourists has been described *as awfully grand and sublime.* This, however, is too poetical; but although it will not bear comparison with that of the Clyde, or even with many of the lesser waterfalls in this country; yet it is really a very interesting object, and its situation is retired and romantic. The cascade is received into a natural rock-basin or *kieve,* from which it escapes and flows murmuring over its pebbly bed, through a deep and narrow glen which is prettily wooded.

At the point where the water rushes over the precipice, the rock on each side forms a narrow channel of two or three feet in depth; which appears to have been excavated by the action of the stream: but the sides and bottom of this channel are covered with an uniform coat of vegetation, indicating that

* I have been lately informed that beds of calcareous rocks occur in the cliffs of this cove: and that the caverns are lined with stalactites.

no abrading process is now in operation. It is most probable that this channel, as well as the defile beneath, was not formed by this insignificant rivulet; but became subservient to it, as affording an unobstructed egress to its waters.

The rock which forms the projecting precipice at Nathan's Kieve, is a coarse-grained, greyish, and laminated rock (53.); and immediately adjoining it northward, the hill is formed of a blueish fine-grained slate (54.) which dips N.W. and is similar to the slate on the upper part of North Delabole quarry: indeed it may possibly be a continuation of the same stratum.

Crossing over the fields from Nathan's Kieve to the village of Trethevy, about midway, there is a furze-croft, on the surface of which project several masses of a compact rock. Having observed a gate hung on a block of this stone, I traced it to this place, and was so fortunate as to find a part of the ground opened for raising hedging stones. This rock (55.) is green and glossy; it is foliated, tough and effervesces with acids:—it is of the same nature as the calcareous rock of Grylls, only of a finer and more uniform texture. The same kind of rock, I have since been informed, occurs near Tintagell point: but it escaped my notice. At Trethevy, slate (56.) again occurs; it is of a light colour, with ochreous stains. A similar kind of slate (57, 58.) extends to Trewothat, near Trevalga church:—No. 59, is a specimen of the slate at the latter place.

On the north side of the village is an extensive, though shallow quarry; where the slate (60.) is

raised in slabs, so large and strong, that they are used for making sheds, fences, stiles, and for similar purposes.

At Wildtown, the slate (61.) is bluеish and speckled with hornblende. In the cove below, and on the side of the cliffs, are several quarries of roofing slate. Very considerable quantities of these slates (62, 63.) are raised; and are generally known by the name of *cliff slates;* they are sold at a lower price, than those of Delabole, and their inferiority appears to consist in becoming *weathered* on exposure to the air. This slate, when first raised, has a good colour, its surface is granular, and minute particles of iron-pyrites are visible throughout; to the decomposition of which, the *weathering* of these slates must be attributed. Many blocks of *limestone* may be seen in the walls of Forrabury church, and the granite cross which stands outside the church-yard is fixed in a mass of this stone: it may, therefore, exist in the neighbourhood, but I could not discover it.

South of this church, the ends of the strata *basset* out on the side of the hill, dipping northward at an angle of 20°. This rock (64.) is slate, which has that spangled appearance noticed in the neighbourhood of Trewarnet. A longitudinal section of this rock is also exposed on the road from Boscastle to Valency Bridge, which exhibits a good example of the curved structure of rocks. The adjoining promontory of Pelly Point also presents many sections illustrative of the same conformation. Here the slate (65.) is of a dark colour, its texture is granular, and it contains

a considerable portion of iron-pyrites. This kind of rock prevails along this part of the coast: it is very prone to decomposition, and in some cases becomes a black earthy mass which soils very much; and on this account it has been supposed to contain manganese, which mineral is well known here, in consequence of its being brought, in considerable quantities, to the port of Boscastle for shipment. A disintegrated stratum of this sort (66.) occurs in Willapark cliff, a little to the westward of Forrabury church; and is imbedded in slate (67.) similar to No. 65. This slate contains layers or beds of a carbonaceous mineral, (68.) which has a metallic lustre on the face of its laminæ, is soft and soils much; it deflagrates when thrown into red-hot nitre.

I am indebted to Mr. Wm. Petherick, of Lanescot mine, for this specimen, and for the knowledge of its occurrence in Cornwall. He informed me that he was induced to search for it, in consequence of the great resemblance of these rocks to those of Devon which contain coal: and having found a favourable spot, he got assistance to remove the decomposed part of the rock, under which he discovered this carbonaceous mineral.

On examination I find, that these dark pyritiferous slates owe their black colour to a portion of this mineral: so that this carbonaceous substance is occasionally aggregated into distinct veins or layers, in the same manner as calcareous spar in limestones, and quartz in rocks that abound in silica.

The rocks between Pelly and Fire-beacon Points

contain very large veins, or rather layers, of quartz running parallel with the strata; and in some instances, as may be seen on the western side of Pelly Point, even following the most capricious curvatures of the slate. In the little cove, midway between these points, (about a mile to the eastward, and on the right-hand side,) is a perpendicular cliff, in which are several thick layers of quartz one above another, in an horizontal position, with the slate intervening; so that they might be mistaken, if viewed in this solitary instance, as alternating strata of slate and quartz-rock. They are, however, only contemporaneous veins, for innumerable examples occur in this neighbourhood, where similar veins may be seen throughout their whole extent.

It may also be remarked, that here also, as well as in the places already alluded to, the rock immediately in contact with the quartz veins is harder, and apparently more siliceous: it also sometimes happens, that imbedded in these rocks, there are certain layers of a harder rock full of numerous quartz veins, as observed at Crackington Cove; and again the quartz veins are entirely wanting, and in their place, (if the expression may be allowed,) occur strata of hard compact rock, in colour and composition apparently the same as the slate in which they are imbedded, but which have not their lamellar structure. It is, therefore, probable that the silica, which in other parts of the stratum forms quartz veins, is in this case intimately united with the substance of the slate. The compact rock (69.) and that (70.) with

veins of quartz, were obtained from a road-quarry on the side of the hill, about half a mile from Valency Bridge, on the Launceston-road.

A little farther on, to the right of this road, at Tresuck, is another quarry, the slate of which (71.) is of a darker colour than the preceding: the joints of this rock are full of thick flakes of iron-pyrites; and the same mineral is very abundantly disseminated throughout the substance of the slate; it does not alter its colour in the streak, so that it resembles the alum-shales. Iron-pyrites enters so abundantly into the composition of these rocks, that it is entitled to be considered as a constituent part, and not as an imbedded adventitious mineral.

About half a mile farther north, at Battens, the slate (72.) is similar to that just mentioned; it only differs in the surface of its laminæ being striated.

Near Higher Bany, north of Battens, a dark glossy pyritous slate (73.) occurs; and continues to Tresparrett Downs.

From St. Breward to Endellion, and thence to Padstow Harbour.

Returning to Rough-Tor, and proceeding thence in a south-westerly direction to St. Breward, the only rock passed over is granite, which (74.) is similar to that of Brown-Willy, and Brey; with the exception that the mica is rather more abundant.

The church of St. Breward is situated on the top of a hill which descends rapidly and steeply to the

westward; and immediately opposite is another hill of the same form and inclination: the glen thus formed, between these hills, is deep and narrow, affording a passage for the river Camel. The upper part of St. Breward's hill is covered with projecting masses of granite; but, about midway on the descent to the river, these suddenly disappear; and corn-fields and coppice-woods succeed, indicating an improvement in the soil, and a difference in the subjacent rock.

The junction is not exposed; but at a farm-house, about a hundred yards from the granite, a schistose rock protrudes from beneath the soil: and on crossing the river, (at Combe) the same rock also presents itself at Penrose, a farm-house on the top of the opposite hill; and is there distinctly seen dipping west, at an inclination of 45°. This rock (75.) appears to be a variety of mica-slate: it divides into thin laminæ, the surface of which is shining and micaceous; but on the cross fracture it is dull and somewhat granular: these grains are not quartz as in the most perfect type of mica-slate; but judging from their inferior hardness, and their appearance when disintegrated, they probably contain felspar. In many parts of Cornwall the slate has, on a newly fractured surface, very much of this micaceous appearance, particularly that which occurs on the north side of Truro: but this is merely a superficial gloss. The slate of St. Breward, however, appears to be composed of granular felspar, interlaminated with mica: and its geological position in immediate contact with the granite, is in favor of its being

considered a variety of mica-slate. This interesting rock may be traced from thence for several miles, running N. and S., parallel with the granite, in the direction of Michaelstow and of Blisland. A bed of a hard massive rock (76.) which appears to consist of compact-felspar and hornblende, (resembling the greenstone of Pencarrow near Camelford,) occurs a little to the north of Penrose; but in what manner it is connected with the mica-slate was not evident.

About half a mile to the east of St. Tudy, the hornblende-slate (77.) appears, and intermixed with the massive varieties of this rock, continues through St. Tudy, and about a mile farther to the westward. Turning northward to St. Teath, about half a mile from the latter, is Treburget mine: which is situated in a blue pyritous slate (78.) traversed by lodes running N. E. and S. W., varying from two to five feet in thickness. These lodes (79, 80, 81, 82.) contain galena, blende, iron-pyrites, and spathose iron-ore; and their matrix (83.) consists of angular pieces of slate, like fragments, cemented together by quartz: the angular form of these fragments indicate that they have not been transported from a distance, which is confirmed by their being of the same nature as the adjoining rock.

In one part of this mine, all these substances are found in an unconsolidated state like gravel; but under what particular circumstances I could not learn, the Captain being absent, nor have I as yet received an answer to my enquiries.

The slate is also traversed by a cross-course of a

in the cross fracture it is exceedingly tough. It dips to the N. W., at an angle of 30°. The same kind of rock also occurs at Padstow Harbour, in the cliffs between Hell Bay and Pentire Point.*

The Downs between Endellion and St. Minver, are covered with fragments of a rock, (94.) which is somewhat similar to the last, in composition; but it is rather schistose, and not amygdaloidal: I did not see it in *situ*, but there can be little doubt that it exists under the soil. The same kind of rock, (95.) but more massive, is found on the Camel, immediately above the point at Dinham, and from the direction it may possibly be a continuation of the rocks which have just been described. It is not unlike, in appearance, the massive felspar-rock of Mount's Bay, exhibiting when wet a bright mixture of colours, in which violet predominates. It is massive and granular, and exceedingly tough; but when a fragment of it is thrown into dilute acid,

* Since writing the above, Mr. John Prideaux, of Plymouth, has presented to the Society specimens of rocks, illustrative of his Geological Sketch of the country between the rivers Plym and Tamar, amongst which is one from Crabtree resembling that of Port Isaac, and is thus described. "This greywacké, here called '*Dunstone*,' is generally compact, and hard enough to make a good road-stone. It suffers from the weather, (particularly where it happens to present an eastern face, south of the granite,) mouldering and becoming honeycombed, the hollows containing ochreous matter. It is often disseminated with amygdaloid granules of limpid crystallized carbonate of lime, and sometimes of black shorl,—and it generally returns the odour distinctive of hornblende, when breathed on. Veins of quartz, accompanied with pulverulent black oxide of manganese often occur, particularly in the slaty portions; and the latter substance occasionally fills the pores of the exposed rock, instead of the ochreous matter above mentioned. It is very fusible before the blowpipe, which, joined to its susceptibility to the weather, seems to indicate its containing an alkali." Transactions of the Plymouth Institution, Vol. 1, p. 32. The latter observation in some measure confirms the opinion above advanced,—that the basis of this rock is compact-felspar.

it effervesces slightly; this action, however, soon ceases, owing to the great cohesion of its particles, and the protection of the calcareous portion by the hornblende and other component parts: for when reduced to powder the action is more free, and the hornblende and felspar remain as sediment.

At Dinham is a limestone-quarry near the road-side, and from the position of this bed, it is probably in contact with that of the compact felspar-rock just described.

Around St. Minver a yellow slaty rock (96.) prevails; it is rather soft, and separates easily into thick laminæ of a rhomboidal form; it is evidently in an altered state, the perfect rock is probaly a variety of hornblende-slate.

Imbedded in this slate, between St. Minver and Trevanger, is a massive rock similar to the last; in the upper part of the quarry the rock (97.) is in a decomposed state; beneath this it (98.) is but partially disintegrated, and appears to be a crystalline compound of hornblende and felspar.

Between Dinham and Rock Ferry, on the Camel, hornblende-slate (99.) is the only rock exposed to view: but at the latter place this slate contains beds of dark blue limestone, (100, 101.) abounding in veins of calcareous spar. This stone, known provincially, under the name of *black lime*, will burn into an excellent lime, partaking somewhat of the nature of that from Aberthaw. The upper part of this stratum gradually passes into hornblende-rock, as may be seen in the specimens, Nos. 102, 103, 104.

Here I think that the relation of the limestone and the hornblende-rocks towards each other is clearly shewn: and appears to be applicable to all these rocks in this part of the country;—viz. that the limestone does not form an independent stratum, but is intimately connected with the adjacent rocks, all of which contain a portion of calcareous spar; and from which, it only differs in holding this mineral in excess. And, if this view of the subject be correct, this limestone may be regarded as the equivalent of the porphyries in the strata adjoining the granite.

From Rock House to Trebetherick, about half a mile north of St. Enodock, the country consists of immense sand-hills: at this village slate again appears, and may be traced along the cliffs to Pentire Point. This slate, when perfect, is rather hard, it does not break into regular laminæ, but is splintery in the fracture, resembling honestone or novaculite: the most abundant kind is of a dark reddish brown, (105.) which is frequently intermixed with (106, 107.) greenish and yellowish grey beds; indeed all these are often blended together in patches, spots, and stripes. These strata dip N.W., at an angle of about 20°. and are traversed by hornblende and limestone rocks.

In a little creek near Polzeath, in Hell Bay, the side of a large lode is exposed to view, it consists principally of quartz, with imbedded portions of black and grey slate. In appearance it very much resembles the lode of Treburget mine, at St. Teath, as already described: and indeed from the position of these places, it may possibly be one and the same

lode. It is exposed for several hundred feet in length; but it has such a curved form, that it is not easy to pronounce the direction of its dip:—but the angle of inclination is uniformly 55°. Several large fragments of this lode have fallen down, and being worn by the sea, the surface distinctly shews its nature: which in a hand specimen (108.) is not very apparent. This fragmentary appearance of lodes is of more frequent occurrence in Cornwall than is generally known: I shall have other instances to notice, and will, therefore, defer this subject for the present.

From Blisland to Wadebridge: and around Bodmin.

To return again to the granite district:—this rock (109.) occurs about one mile east of Blisland; and is succeeded by hornblende-slate, (110.) containing beds of (111.) compact hornblende-rock: these rocks continue to Key Bridge, where the slate (112.) is more decomposed and argillaceous. In the neighbourhood of St. Mabyn, the rock is a red and grey slate, in appearance like that of Padstow Harbour; but it is not so hard, nor splintery in the fracture. It dips N. W., and extends from St. Mabyn near to St. Tudy, and in a westerly direction beyond the high-road from Wadebridge to Camelford. The specimens, Nos. 113, 114, were obtained at a quarry a little to the north of Trethevy, which is about midway between St. Mabyn and the above mentioned high-road. This rock is succeeded by

hornblende-slate (115.) about the second mile-stone, and continues to Wadebridge; and between these places it is traversed by a hard massive rock (116, 117.) which affords a good material for the road; it has the appearance of compact-felspar, penetrated by numerous veins of calcareous spar; and it seems also to contain a portion of this mineral in its composition, as it slowly effervesces, in dilute muriatic acid, when previously reduced to powder.

A little more than four miles from Bodmin, on the Launceston-road, is the boundary of the granite; which rock has the same characters as those already described. About half a mile from the junction, a hornblende-slate (118.) occurs in a quarry by the road-side: and a similar rock (119.) extends over Baron Downs.

On the north-western side of this down at Kernick, about three miles from Bodmin, on the Camelford-road, is the same kind of schist (120.) which is here traversed by a bed of granitoid rock. (121.) Some parts of this bed is more compact, (122.) and contains a portion of hornblende. This rock runs N. E. and S. W.: it is exposed for about twenty feet; but its junction with the slate, on either side, is concealed; so that its size and bearings could not be ascertained: it is probably an *elvan-course*. On the top of the next hill, near Smiths, about half a mile nearer to Bodmin, another kind of *elvan-course* is exposed to view, in consequence of the road having been lowered. I first observed fragments of this rock (123.) at the bottom of the hill, and was much

struck with its appearance; for it more resembles a granitic sandstone (produced by the consolidation of the transported *debris* of granite) than any other rock that I have seen in Cornwall. The upper part of this course is visible in contact with a rock like No. 113. It is unchanged at the junction: where there is no appearance of transition, each rock being perfect and distinct. This circumstance seems to shew that there is a difference between this rock and the *elvans;* for the latter, as far as my experience goes, gradually pass into the adjacent strata.

This *course* appears to dip southward, at an angle of 30°.: its bearings, however, were not so evident as to enable me to be decided on this point: and I was not successful in my attempts to discover it in other parts of this neighbourhood. The farther investigation of these numerous beds of granitic rocks, between Bodmin and Camelford, is deserving of the Society's attention.

Two miles from Bodmin, on the same road near the Race Course, a similar kind of hornblende-slate (124.) occurs; and continues within a mile of this town. At a quarry, near the Bodmin turnpike, on the Launceston-road, the rock is altered in character; it (125, 126.) is much more argillaceous than the preceding, is not so lamellar, but separates into thick flags; it prevails in the neighbourhood where it is extensively quarried for building, for which purpose it is well adapted. No. 127, is from near the western turnpike, and Nos. 128, 129, are from the hill descending to Dunmeere Bridge, on the Wadebridge-

road. In the upper part of these quarries the stone is yellowish white, stained with red; but lower down it has a bluish tint, and the deeper the quarry is sunk the bluer the stone becomes. These strata dip N. E., at an inclination of 25°.

The nature of this rock, owing to its altered state, and to its contact with other rocks not being exposed, is rather obscure. But as it occupies a considerable space I thought it worthy of particular examination, and I therefore endeavoured to trace its connection with the strata nearer the granite; but could not find the rocks exposed in any situation favourable to the enquiry. In repeatedly traversing this part of the country, I at last met with a rock on the side of a hill between Bodmin Downs and Castle Kenyoe, which appears to throw some light on this subject: it (130.) is of an ash grey colour, and consists of an intimate mixture of fine granular felspar, and a shining micaceous mineral, and is liable to extensive decomposition like the slate of Bodmin. The transition between these rocks seem to be easy; for that of Bodmin, being of a somewhat finer and more uniform texture than the rock at Kenyoe, may be owing to the constituents being more thoroughly blended together. Between St. Breward and Key Bridge the mica-slate, by the gradual disappearance of the mica, passes into a slate also resembling that of Bodmin: this rock may, therefore, be composed of granular-felspar, slightly coloured by mica, hornblende, or some analogous mineral. This lamellar slate occupies a position which is nearly equidis-

tant from the granitic groups of the eastern and central districts, into which it mutually passes on either hand. It is such a distinctly characterized rock, that it ought to have its peculiar name: perhaps that of *argillite*, which is not much in use now, would be appropriate.

From Blisland to St. Neot: and thence southward to Polruan.

Near the fourth mile-stone on the highway from Bodmin to Launceston, a road turns off to the right leading to Liskeard, and for two miles, as far as Cardinham, it runs parallel with the granite, over a rock very similar to the mica-slate of St. Breward. Here, however, this slate (131.) only presents itself in very shallow sections by the road-side, and is consequently in a state of partial decay. It dips S. W., at an angle of 35°. Imbedded in this rock at Treslea, (on the side of the hill just as you enter on the downs,) the upper part of a bed of felspar-porphyry (132.) is exposed to view: but this also is in a state of decomposition; and it is not sufficiently denuded to shew its bearings. From the latter place over the downs to Panter's Bridge, the rock appears to be a similar kind of slate to that of the downs N.E. of Bodmin; it also succeeds the same kind of micaceous slate, and like it abounds with massive quartz veins. Near Panter's Bridge the rocks (133.) are more compact, resembling hornblende-slate; and contain beds of compact-felspar. At St. Neot,

the slate (134.) is finer grained and bluer. A copper-mine, not far from the church, is worked in this rock, the lodes of which run east and west, and principally consist of quartz. About a quarter of a mile south of St. Neot, the slate (135.) appears to be the same as the last, only it has lost the blue colour, and become a yellowish grey in consequence of a partial change. A mile farther south the slate is more fissile, and is quarried for economical purposes: my specimen of this rock was lost.

At Lawharn, a similar kind of slate (136.) prevails, though much decomposed. After passing the woods the extensive downs which extend southward, appear to rest on the same kind of slate, but abounding so much in quartz, both imbedded and in veins, that little else is to be seen than blocks and nodules of this mineral, with more or less of the slate disseminated throughout its substance.

Proceeding southward to Polruan through Botallick, Trevallard, and Trehire, the rocks are so concealed, that I could not obtain specimens: but judging from the *weathered* stones in the walls of the cottages, and in the hedges, they appeared to be of a similar nature to those about to be mentioned.

At Lantegloss, a coarse, earthy, blue slate (137.) occurs: and at Polruan, the same kind (138.) of slate: both of these contain minute spangles of mica, and are traversed by quartz veins; and alternate with beds of a massive quartzose rock, (139.) somewhat resembling a very fine-grained sandstone. All these rocks dip northward, at an angle of 30°.

From Polruan to East Looe.

The last mentioned rocks occur on the coast, both at Lantivit and Lantioc Bays; proceeding thence inland to Lansallos, the slate is more lamellar, dividing into large thin slabs; and it (140.) also differs from the last mentioned slates, in being of a red colour, which I am inclined to attribute to the farther oxidation of the iron which enters into its composition, as already noticed in the rocks at St. Tudy: for immediately to the N. W. of Lansallos is an old copper-mine where the same kind of slate (141.) is seen near the surface; and amongst the rubbish, a blue slate (142.) which only differs from the last in colour.

The same kinds of rocks extend to Polperro, and thence through Talland to Looe: Nos. 143, 144, are specimens of the slates from Polperro, and No. 145, of the more compact rock which breaks into massive laminæ, and is more micaceous and argillaceous than the equivalent rock at Polruan. These strata all dip north, at an angle of 45°.; so that the country rises into high hills towards the sea, where it is also intersected by deep and narrow valleys or *gullies*, through which some insignificant rivulets discharge their waters into the ocean. The entrance of the harbour of Polperro affords the best example, that I have met with in Cornwall, of the action of a mighty torrent on the strata of the earth. Here, the hills, on each side, are curved at their summits towards each other; but, after a short descent, ter-

minate in bold perpendicular cliffs, from the sides of which craggy portions of the strata protrude: all of which have the same dip to the north. Below high water-mark the strata are firm and perfect; all decayed parts being removed by the action of the waves: but above the influence of the sea, the rocks are in a decomposing state. From the appearance of these hills, there can be little doubt, but that they extended across the mouth of this harbour in the form of a concave curve, the lowest part of which was above high water-mark. If this were the case a lake must have once existed here: but my stay was too short to search for lacustrine remains in support of this conjecture; and indeed such an enquiry might have been in vain: because, as the valley to the north inclines rapidly towards the sea, all such deposits were probably swept away, when the *gorge* was formed. At what period this did take place is not easy to determine: but there is ample evidence that it has been produced, not by the usual and unceasing action of the elements, but by one of those extraordinary convulsions of nature, by which our globe has been periodically visited.

At Talland, the rocks are of the same nature: but the slate (146.) is rather greener and more glossy, like No. 141, from the mine at Lansallos.

The rocks around Looe are very like the last: Nos. 147, 148, are from West Looe; and Nos. 149, 150, from East Looe, from a quarry at the top of the hill on which this town is situated. These strata dip S. and S. E., at about 30°. to 40°.

From East Looe to the Granite Hills north of St. Cleer.

About a mile and half north of East Looe, the slate (151.) is blue and shining; and breaks into laminæ, the surface of which is very irregular. Near St. Martins it contains beds of a massive rock, (152.) in which is a large portion of carbonate of lime; like the rocks adjoining limestone.

Half-way between Looe and Liskeard, at Bin Downs, the country rises into an elevated ridge which is barren, and covered with blocks of a coarse kind of quartz-rock, (153.) consisting apparently of an intimate mixture of quartz and slate; the former, however, is predominant. This kind of rock, which will be often noticed in the following pages, appears to be common to all those districts in the slate formation, where high and barren hills occur. It abounds in immense masses and veins of quartz, which is sometimes white and pure, but more commonly is intermixed, or penetrated, uniformly by that kind of slate which lies contiguous to this rock, with which it is also oftentimes interstratified, passing mutually into each other.

Descending northward, the slate (154.) breaks into more uniform laminæ: and about two miles from Liskeard, at West Clicker, contains beds (155.) of compact hornblende-rock.

About a mile from Liskeard are several large quarries, in which a coarse slate is raised as a building stone: it (156.) is of a dirty yellowish brown

colour, irregularly and indistinctly marked with blue spots, but which become more prevalent as the works become deeper. It seems to me to be a slate having a basis of granular felspar, with a combination of hornblende, but in so small a proportion that it cannot, with propriety, be called hornblende-slate.

Quarries of a similar kind of stone (157, 158.) also occur about one mile north of Liskeard, on the road to St. Cleer: the strata here dip towards the S. W., at an angle of 30°. Still proceeding northward, hornblende becomes a more evident constituent of the rocks, and it gradually increases in quantity as the granite is approached, till at length it becomes, at St. Cleer, the prevailing ingredient. A kind of hornblende-slate (159.) occurs at the foot of a hill, about midway between Liskeard and the granite; the strata dip as the last, southward.

The large down, between the last place and St. Cleer, is composed of (160.) hornblende-slate; and is strewed over with bowlders of greenstone, (161.) in some parts of which the hornblende is distinctly crystallized in shining laminæ. These blocks of stone may be found more than a mile distant in the valleys to the south; and they increase in number as you ascend to the highest part of the downs, where the greenstone appears in *situ*, forming a craggy ridge, bearing N. W. and S. E. This rock, in the vicinity of the church, is said to contain veins of asbestus, but I did not observe any.

In the valley immediately N.E. of St. Cleer, which extends up to the granite hills, are some immense

masses of compact-felspar, (162.) very crystalline in texture, and nearly as hard as quartz: they are only slightly corroded on the surface by the action of the elements. Whether they form the *out-crop* from a stratum beneath the mound on which they rest, or whether they are diluvial, is not apparent: the latter appears to be more probable; but their native bed cannot be far distant, for the adjoining hornblende-rocks are, without doubt, intermixed with layers of compact-felspar, as in other parts of Cornwall.

As you ascend the granite at Downhill, about a mile north of St. Cleer, the moor is covered with bowlders of (163.) a beautiful snow white quartz. The first granitic rock (164.) which is found in *situ*, contains a larger portion of shorl than is common in this district; the mica being also in the usual proportion. Towards the top of the hill is a fine-grained granite, (165.) in which the ingredients of the former are so intimately united, as to form a granular basis, having imbedded crystals of flesh-coloured felspar. Coarse layers also occur, (166.) containing more quartz, shorl, and mica, than felspar. And quartz veins also abound, from which the bowlders, No. 163, were probably derived. On Carraton Hill are several extensive excavations, the remains of old workings for tin: and near one of these is an abandoned mine. Judging from the fragments around, and from a few shallow excavations at the surface, the mine is situated in a fine-grained granite, the upper part of which, for a considerable depth, is partially decomposed, being of a reddish brown

colour, and porous; not unlike some kinds of brick. This rock (167.) is derived from a very compact granite, (168.) consisting of minute grains of red felspar and quartz, with a greenish mineral resembling hornblende: this rock is similar to that of No. 122, which occurs as an *elvan-course* imbedded in the slate at Kernick. The lode of this mine is quartz, the greater part of which is intimately combined with shorl, producing a dark coloured rock, (169, 170.) such as is common in those parts of Cornwall, where this mineral abounds; and which will be more particularly noticed in the chapter on the central district.

FROM CARRATON HILL TO RAME HEAD.

Descending from Carraton Hill, and proceeding southward, the granite is left near Newton: and between the latter, and a place about a half a mile south of Rosecradock, the same kind of rock occurs as around St. Cleer. The hornblende-slate (171.) at Rosecradock, is of a blue colour, and very fine-grained; separates into thick rhomboidal laminæ; dips S. E., at about 30°., and contains beds of compact-felspar, No. 172.

At Trengove, about a mile south of Rosecradock, the slate (173.) is more granular: its constituent parts appear to be the same as those of the last mentioned rocks, though in somewhat distinct concretions.

Near Pengover, on the road between Liskeard and Callington, about one mile and half from the

former, the rock (174.) is a kind of greenstone, containing numerous minute facets of calcareous spar.

This is near the spot, where the Reverend Canon Rogers has informed the Society that limestone occurs. I did not observe this rock: but from the intermixture of carbonate of lime in No. 174, it is very probable that it may exist there; I should, however, have liked much to have been able to decide this matter, on account of its position with regard to the serpentine about to be noticed: for although I have often seen carbonate of lime in the strata inferior to serpentine, I have not detected limestone in such a situation.

From Pengover to Clicker Tor, the only kind of rock exposed is hornblende-slate, like No. 156, which is quarried for a building-stone. The massive rock that forms the hill of Clicker Tor is serpentine. It (175, 176.) in a perfect state, is of a dark bottle-green colour almost approaching to black: and when closely viewed, it is found to be spotted with greenish white particles which are softer than the other part of the mass, and somewhat resemble steatite.* It is traversed by numerous veins and patches of amianthoid asbestus, (177.) which is beautifully white and very silky. At the joints, this rock is frequently of a bright green, smooth and glossy, owing to a thin layer of common asbestus (178.) being interposed.

I could not find this rock in contact with any other; nor could I ascertain its extent: but it is

* The Rev. Mr. Gregor gives it as his opinion that this substance is compact tremolite. Trans. Geo. Soc. of London. Vol. III. p. 400.

probable that the peculiarly formed hill in which it occurs, marks the limits of this formation.

On descending the hill to Buckapit Bridge, about a mile from Clicker-Tor, the road is cut down through a friable glossy slate (179.) of a fawn colour, which is in a state of partial decomposition. And about a quarter of a mile farther south, on the opposite side of the valley, a coarse calcareous schist (180.) is quarried as a hedging stone: on the surface of the laminæ it is of a dark blue, with a resinous gloss, and bespangled with very minute particles, having the appearance of mica; the fracture, in the direction of these laminæ, is wavy and irregular; the cross fracture is shattery and splintery, and of a light bluish grey colour, and the texture is like that of limestone: it effervesces strongly in diluted acids.

About ten miles from Tor Point, near a place called Tinker's Lake, is a roofing slate quarry. This slate (181.) is dark blue, and the surface of the laminæ is not quite smooth, but imperfectly fibrous; the cross fracture is of the same colour and earthy. This stratum, like the preceding, dips a little east of south, at an angle of 30°.

In the hill from thence, about half a mile nearer Tor Point, a massive rock (182.) occurs, the composition of which is curious: its base is of a dark grey, and finely granular, in which are imbedded globules, varying in size from that of a pea to that of snipe-shot; internally they are white, but are slightly coated outwardly with a greenish substance which is much softer than the other part. These

globules have much the appearance of quartz, but though hard they yield to the knife: they do not effervesce with acid. This rock is not unlike that of Grampound, which resembles greywacké more than any other Cornish rock, with the exception of the conglomerates at the Nare.

A little farther south, a dark blue glossy slate (183.) succeeds: it separates easily into thick rhomboidal laminæ, which are again fissile into thin leaves; but these, on account of the numerous joints by which they are intersected, are not continuous enough to form roofing slates. A massive rock (184.) appears to exist in this slate, as it is abundant in the hedges, and on the road-side; but I did not see it in *situ:* it is a kind of greenstone, having a more granular texture than the basis of No. 182.

About nine miles from Tor Point, near Trerule Foot, is an extensive limestone quarry; where the stone is raised in large blocks, which are traversed by numerous veins of calcareous spar. This limestone (185, 186.) is of a dark blue colour, and very glittering, owing to the numerous resplendent facets of calcareous spar disseminated throughout the mass; it is compact, and very hard: it is burnt into lime on the spot, the quality of which appears to be good. The rock (187.) on each side of this limestone, is the same kind of blue slate as No. 183: and is more or less calcareous according to its proximity to the limestone.

Similar kinds of calcareous slate (188, 189.) are met with about eight miles from Tor Point, near

where the road turns off to St. Germans. At Polvathic, about one mile farther south than the last, is a compact rock, (190.) of which quartz, or rather silica, appears to be the predominant ingredient, intimately blended with the matter of the adjacent argillaceous slate.

From this place to Tor Point only one kind of slate (191.) is exposed to view; and this is generally in such an altered state, that its nature is very obscure: it also contains compact rocks (192, 193.) at Polscove, similar to No. 190, but more disintegrated, and stained by oxide of iron; and at Anthony the compact rock (194.) only differs from the last in being of a lighter colour and more granular.

At Crimble Point, (the most northern part of Mount Edgcumbe,) is a crystalline limestone (195.) which is mottled and veined with flesh-coloured calcareous spar. From its position, it is probably a continuation of the same stratum that is so extensively quarried on the eastern side of the harbour, and which abounds in organic remains. I regret that I was not able to ascertain the nature of its connection with the adjoining strata.

Following the coast southward, a grey coloured slate (196.) first presents itself, and is succeeded by a massive rock, of which there is a fine section in Edgcumbe-hill as far as Redding Point: and the shore throughout this space, is covered with massive blocks and bowlders of the same rock, derived from the destruction of the adjacent cliff. It is not easy to determine the bearings of these strata; for in

some parts they appear to dip east of south; and in others, west of south; and about midway the inclination seems to be to the north west, passing immediately under Mount Edgcumbe.* This discordance is probably only apparent; for, as has been often remarked, the strata are always more or less curved, and traversed by a three-fold set of joints or seams: so that it is very difficult, more especially when the massive and slaty rocks are not seen in contact, to decide which of the exposed parallel surfaces indicate the direction of the strata.

These rocks of Edgcumbe, both schistose and compact, are of the same nature as those already noticed between Polvathic and Tor Point: but as they are better displayed here, they merit a more minute description. The most perfect layers of the compact rock are of an iron-grey colour, (197, 198.) of a fine granular texture, crystalline and very hard: this rock is composed apparently of silica with a portion of an argillaceous mineral, which is probably a kind of granular-felspar; and contains a black mineral, in the form of minute crystalline *spicula*, sparingly scattered here and there, which looks like hornblende; but whatever it may be, it is without doubt the colouring ingredient of this rock. Some of the layers (199, 200.) are much softer than the

* Dr. Berger states that these strata "dip S. S. E., at an angle of about 65 or 70 degrees, which is nearly the same as that of the limestone cliffs of Plymouth Harbour." Trans. Geo. Soc. Vol. I. p. 114. The Rev. R. Hennah, however, observes that the position of nearly all the stratified rocks in this neighbourhood is from N. W. to S. E., dipping towards the S. W. Idem. Vol. IV. p. 410.

last; and are partially decomposed, owing, perhaps, to the felspar being in a larger proportion: they are of a deep red, speckled with white spots; and these coloured parts (201.) are sometimes arranged in distinct stripes. The red portion of these strata may be seen in the various stages of cohesion, from that of a hard rock to a state so soft, that it will crumble under the pressure of the hand.

These rocks may therefore be composed of felspar, quartz and hornblende, or an analogous mineral; differing only from the greenstone that occurs farther north (nearer the granite) at Saltash and St. Germans, in abounding more in quartz than hornblende. Their layers assume various characters according to the proportion in which the constituents are blended together: thus, those that are quartzose, are but slightly affected by the elements; whilst those, in which felspar abounds, are more susceptible of decay: the colour of the disintegrated mass depends on the proportion of the hornblende; and, according to the mode in which this mineral is distributed arises the spotted and striped appearances of this rock.

From Redding Point to the village of Cawsand, the cliffs and sea-shore only exhibit a red sandstone, (202.) which is generally considered to be an argillaceous variety of the *old red sandstone*.

From Cawsand to Rame Head, the cliffs are composed of alternate layers of slate, (203, 204.) and of compact quartzose rocks, (205,) the same as those of Mount Edgcumbe; some of the schistose strata are of a red colour, and others, of a greenish grey; but

in other respects, they are apparently of the same nature. The three last specimens were obtained at Penlee Point, where the laminæ of the slate are perpendicular: but these are traversed by joints that incline to the west of south, at about 45°., and which may, therefore, be the true direction of the stratum.

Such are the rocks that present themselves between the granite and the Rame Head. Throughout this tract the different rocks cannot often be seen in contact with each other, and therefore the nature of their connection cannot be decidedly pronounced: but judging from the few opportunities that do occur, and from the gradation that exists in their mineral composition, it appears to be very probable that all these rocks are of contemporaneous origin, with the exception of the sandstone at Cawsand, and also, perhaps, of the limestone at Crimble Point which is said to be a continuation of that of Plymouth. It may be objected to the first exception, that the red sandstone exactly resembles the decomposing part of the quartzose rock of Edgcumbe, through which it is connected with the series of rocks ascending to the granite: but this resemblance only shews that the sandstone has been formed from the *debris* of these quartzose rocks, which has undergone little alteration in its composition, because it has not been transported far from its source. Concerning the limestone I have no remark to make, because I could not ascertain its relations to the rocks at Edgcumbe; but should it prove on farther examination to be contemporaneous therewith, and also

of derivative origin with imbedded remains, then it will be important to enquire how far this formation extends. Many have contended that the whole of the calcareous series as far as, and even including, the serpentine of Clicker, is secondary: if it be so, the connection between the latter and the granite, by successive transitions, shew that the latter rock must also be of the same formation.

In offering these remarks I feel it incumbent on me to repeat, that my survey of this part of the country was not so extended, as the importance of the subject required: it is, therefore, to be hoped that the Members of the Plymouth Institution will continue this enquiry, until it is successfully elucidated.

FROM TOR POINT TO CALSTOCK AND CALLINGTON: AND THENCE TO FIVE LANES.

The same kind of slate, that prevailed between Anthony and Tor Point, skirts the shore from the latter to the mouth of the Lynher river: as may be seen in No. 206, from Gravesend Point; and in No. 207, from a projecting rock a little south of Saltash. The slate around Saltash is said also to contain, as at St. Germans, beds of greenstone, of limestone, and of calcareous schist; but I did not meet with these rocks.*

* "There is," says Dr. Berger, "at Peter Point in St. John's Creek, very near Tor Point, a bed of greenstone, in the composition of which there is a good deal of steatite, completely included in the *greywacké*. And not far from this place on the banks of Lynher Creek, there is another bed of greenstone: it is immediately adjoining the ferry. This bed extends from one bank to the

Ascending the Tamar, at Cargreen Point the slate (208.) is of the same nature as the last; but the laminæ are rather more contorted, and striated.

At Pentilly, the slate (209.) breaks into thicker and shorter laminæ, which are not fissile like the preceding: it is of a fawn colour, and has the gloss of the calc-schists, but does not effervesce with acid: it has the appearance of having undergone a partial decomposition, in which state these slates are oftentimes deprived of their carbonate of lime.

On arriving at Cotele, near the landing-place, is a little quarry close to the water-side amongst the trees, the stone of which is much prized as a firestone for lining kilns, ovens, &c. It (210.) is of a light dove colour, and very glossy; it is raised in thick somewhat rhomboidal slabs, which may again be divided into thinner laminæ: in acids it effervesces very violently.

A few fathoms farther up the river this calcareous schist is succeeded by a slate (211.) which rises perpendicular out of the water, and being luxuriantly

other; and on the right or south side of the creek, there is a large quarry of it. Very remarkable differences may be observed in the texture of the greenstone, though the specimens be taken from the same bed. The base is sometimes so close, so homogeneous, that single unconnected specimens of it might pass for *corneous trap* with pyrites dispersed through it: other specimens, however, taken quite close to the preceding, are of a composition and grain between that of corneous trap and greenstone: these are in my opinion sufficient reasons for comprehending all the varieties of this substance, under the common denomination of greenstone." Transactions of the Geol. Soc. Vol. I. p. 115. "Near Saltash," observes Mr. Prideaux, "we have on both sides of the river beds of granular greywacké pervading the slate, and a few thin beds or veins of limestone; and this alternation continues on the east bank down to the Dock-yard, where the limestone formation commences." Transactions of the Plymouth Institution, Vol. I. p. 28.

clothed with wood, becomes a prominent feature in this picturesque scenery. At Calstock, the rock (212.) is the same kind of slate as the last, dipping a little east of south at about 30°.

About half a mile from the last place, on the road to Callington, the slate gradually becomes of a darker blue; and a little farther on, near Alberson, the soil becomes of a reddish brown, and the rock (213.) is a glossy hornblende-slate. Near the fourth mile-stone from Callington, ascending to Hingston Down, the slate (214.) presents itself: it is difficult to name this rock, notwithstanding it is of frequent occurrence in Cornwall, and indicates the immediate vicinity of granite. It evidently consists for the most part of felspar, intermixed with some mineral which imparts a blue colour, and a micaceous glimmering lustre: this substance oftentimes, as the granite is approached, increases in quantity, and then the slate appears to be a variety of micaceous schist, or rather a felspar-slate interlaminated with mica.

At Hingston Down, a patch of granite occurs which is of no great extent, being only about four miles in length; and a mile, or a mile and a half, in breadth: it runs east and west from a little above the Tamar at the *weir-head*, to within half a mile of Callington. In dividing the county into districts, according to the four large groups of granite, this of Hingston, as well as the still smaller one of St. Michael's Mount, were not mentioned, as they may be considered as subordinate thereto. But this arrangement must be considered as purely artificial,

and solely for the convenience of description; for the Hingston granite, in its geological relations, is perfectly analogous to that which forms the respective centres of the adopted districts.

The eastern side of the Hingston granite is extensively quarried, to within a short distance of the summit of Kit Hill, the most elevated part of this range. In the upper part of these quarries, the granite is divided into quadrangular masses by distinct and somewhat open joints, at which it is somewhat discoloured by a partial decay: but as the quarries deepen the stone becomes perfect, and the joints are no longer visible, though the rock still separates into regular layers which are inclined towards the south. The granite (215, 216, 217.) is of the same composition as that of the Brown-Willy range: and like it, is traversed by beds of fine-grained granite, (218.) and by large quartz veins frequently abounding in shorl, and sometimes (219.) with mica; blocks of the latter variety are abundantly scattered on the summit of the hill.

Descending towards Callington, the side of the hill is covered with shallow pits and trenches, apparently made in search of lodes; by means of these excavations the slate (220.) is seen to ascend within a short distance of the top of the hill; No. 221, from about one third of the way from the summit; No. 222, from about half-way; and No. 223, from near the foot of the hill:—all these are the same kind of slate, but are in different stages of decay from exposure to the air; No. 220, nearest the granite, is rather

more micaceous than the others, and No. 223, the most remote, is glossy, but the imbedded mineral is not in spangles, but in the form of minute *spicula* for the most part decayed, and of a rust colour; and are probably derived from hornblende or shorl. This rock on the border of the down passes into an uniform light blue slate (224.); and a little farther on, near the turnpike, hornblende-slate (225.) prevails, containing beds of compact-hornblende-rock (226.); and these two kinds continue to Callington. From the latter place westward, the slate contains less hornblende; and decomposing becomes of a yellowish white, resembling the rock around Liskeard:—No. 227, is from New Bridge; and No. 228, from Thornton, about a mile from St. Ive. At the latter place the rock (229.) has the appearance, at first sight, of a very fine-grained compact greenstone; but it contains numerous shining *facets*, which are soft and effervesce with acids: it is not unlike, though more compact and crystalline, the rock at Pengover already noticed: and as these rocks all dip a little east of south, and are on the same line of bearing, they form, perhaps, part of the same stratum.

Going towards the granite, the proportion of hornblende in the rocks appears to increase; the slate is of a deeper colour, and the soil resulting from its decomposition is redder. Nos. 230, 231, about half-way to the granite, which (232.) makes its appearance a mile and a half north west of St. Ive. Thence back to the Hingston granite is about four miles: the

first rock that presents itself on the nearest hill is a hornblende-slate, (233.) and the same continues to Colborn Down, where, judging from the appearance of the surface, and the immense number of square masses of quartz (collected from part of the down, recently brought into cultivation, to form hedges) the subjacent rock must greatly abound in quartz veins; these, however, are not pure quartz, but contain patches of slate, and is also intimately blended with the same. This down almost touches that of Hingston; and on the western border of the latter are several old mines: from the shaft of one of these, a pale bluish white slate (234.) was obtained; and also a decomposing felspar porphyry (235.): the rubbish around the shaft contains quartz veins with copper-pyrites and galena. I was informed, on the spot, that tin-stone was also raised here: that this and the copper-ore were in east and west lodes, the lead in *contres;* and that the *elvan-course* also lies east and west, and *ran to hill,* traversing the granite. More particular information I could not obtain; but it would be very interesting on account of the position of the granite, and of the lodes.

From Callington to Five Lanes, all the rocks that I met with were compounds of hornblende and felspar; sometimes the latter mineral formed the greater part of the mass; but the former never amounted to such a proportion as to merit the name of hornblende-rock. They may be considered as varieties of greenstone.—No. 236, from Taylor's shop, two miles and a half from Callington: Nos. 237, 238,

from the road-side, about half-way: Nos. 239, 240, from Coade's green: Nos. 241, 242, from Congdon's shop: No. 243, from a quarry about two miles and a half from No. 244, at Five Lanes.

FROM BROWN-WILLY TO LAUNCESTON.

The high-road from Bodmin to Launceston leaves the granite about half a mile before you come to Trewint: at the latter place, is a quarry by the road-side, where beds of massive felspar-rock are exposed to view, dipping N.E., at an angle of 15°. Some of these (245.) consist entirely of white compact-felspar; but others, (246.) are composed of the same mineral intimately combined with hornblende, forming a variety of greenstone, like that at Pencarrow, and other places near this patch of granite.

Greenstones, both compact and schistose, prevail between Trewint and Pollaphant. Descending the hill to the latter place, numerous massive blocks protrude on each side of the road, which (247.) are composed of felspar and hornblende distinctly aggregated, forming a kind of sienite, similar to that, already described, as occurring at Davidstow: the upper part of this hill is barren and rocky, and runs northward from hence, parallel with the little river Inny; to the banks of which its descent is precipitous.

Having learnt that a free-stone of superior quality was formerly quarried in this neighbourhood, I visited the spot which is about half a mile from the high-road. This stone (248.) is, in colour, interme-

diate between greenish and iron grey; it is compact and very tough, but so soft as to yield readily to the nail, and has the peculiar soapy feel of magnesian minerals; it is capable of being turned on the lathe, and of receiving a good polish: in short, it appears to be *potstone*, the *lapis ollaris* of the ancients; and it is a curious circumstance, that several kinds of vessels of this stone were lately discovered under the rubbish of an abandoned quarry, about a quarter of a mile north-west of this place; these were described to me, as resembling *pipkins* and *frying pans*, but in fashion different from those now in use. The oldest inhabitant of this neighbourhood has no recollection of this quarry having been worked.

Lewanick church, and several houses in its vicinity are built of this stone: and it is said that Ensleigh Cottage, a seat of the Duke of Bedford, is also constructed of the same material. The facility with which this stone is worked, being readily cut into blocks, when first raised, even by a common handsaw; and the little labour required to give it a polish, are certainly valuable properties: but the appearance of the loose fragments about the quarry indicate that this stone is very liable to decomposition on exposure to the air, becoming (249.) full of rust-coloured spots, which are derived from a variety of diallage metallöide, which is disseminated throughout the rock in the form of crystalline scales.

This quarry is not constantly worked, as the dèmand for the stone is not great, in consequence of a long and expensive land-carriage.

The workmen informed me that, according to tradition, native silver had been found in this rock; and pointed out an irregular crevice, about ten feet long by one in width, as the place from which it had been extracted. This possibly may be correct, for silver has been obtained from rocks of this nature.

I had no opportunity of ascertaining whether this ollareous serpentine formed an independent stratum, or an imbedded mass in the hornblende-rocks.

The hill on the opposite bank of the Inny is also steep; and is equally interesting to the geologist. The first rock which presents itself on crossing the stream, is a dark blue coloured and glossy slate (250.) which is traversed by minute veins of quartz, and resembles No. 67, from Lesnewth. On the side of the hill at Trenalt, this slate is succeeded by a compact limestone, (251.) containing large veins of white crystalline calcareous spar, (252.) and also minute veins of the same mineral associated with transparent quartz. Many parts of this rock have a shining and silky lustre derived from an intermixture of talc: and others, (253.) are harder and more brittle (probably from a larger portion of silica entering into their composition,) and gradually pass into hornstone, which occur in the form of imbedded masses: throughout this rock small crystals of sulphuret of iron are disseminated. This limestone is extensively quarried: and from the appearance of the large pile selected for calcination, and the report of the workmen, I concluded that this stone would make very good lime. I was, therefore, surprised one day at

meeting two carts, marked 'Alternunn' ascending the hill from the port of Boscastle, laden with lime made from the Welch limestone; and on asking the driver the reason of this, I was informed, that the superior quality of the latter more than compensated for the extra-carriage; the Trenalt lime containing hard lumps which will not slake: owing, no doubt, to the presence of talc and hornstone.

Immediately above this bed of limestone is a grey calcareous schist (254.) which has a fine texture with a shining lustre, and effervesces in muriatic acid. It forms the connecting link, or passage from the limestone into the following (255.) light coloured slate which is very fissile, but cannot be detached in large slabs, in consequence of the numerous natural joints or fissures by which it is intersected. All these strata dip E. N. E., at an angle of about 30°. It is worthy of remark, that the slate which here rests upon the limestone resembles that which occurs, in the same position, both at Trevivian and at Grylls; which renders it probable that these rocks are continuous strata: and indeed their respective bearings are favourable to this opinion; for although the slate at Trenalt inclines more to the eastward than the others, yet this is in conformity to the mass of granite which forms the centre, around which the other rocks appear to be arranged.

On the road to Launceston, about a mile west of the town, a light blue slate (256.) occurs, which is very fissile; and is succeeded by a more massive rock (257.) which has a granular texture.

The rock (258.) which forms the Castle-hill is more slaty; as is seen on the south side, immediately under the Castle; where the strata are exposed, dipping E. N. E., at an angle of 30°.; whilst those of No. 256, do not exceed an angle of 20°. This great inclination will in some measure explain the peculiar form of the Castle-hill, particularly the rapid descent towards Newport : but will not account for its precipitous state on the southern side, which exhibits a cross section of the ends of the strata, as at Forrabury, and elsewhere on the north coast. Some may attribute this to an elevation of the strata; others to a subsidence of the surrounding country:—the appearance of these abrupt and projecting strata certainly seems to record some great convulsion of nature; this subject is very interesting, but being somewhat speculative, its consideration will be deferred for the present.

About midway between Launceston and the Tamar, a bluish coloured slate (259.) presents itself by the road-side: it is of the same nature as No. 256, and has also the same dip and bearings, viz. E. N. E., at 20°.

FROM BROWN-WILLY TO WIDEMOUTH BAY: AND THENCE TO MOORWINSTOW.

The granite appears to continue as far as Shepherd's house; but this is not certain, as the junction is concealed. The first rock that occurs in *situ* is a slate (260.) at Trevaglers; it appears to contain hornblende, but is so much decomposed that it is

not easy to form an opinion of its composition. Near Trevine or Trevinn, where a rivulet crosses the road, strata of limestone jut out from beneath, dipping N. E., at about 25°. This limestone (261.) is similar to that at Grylls and Trethevy, already described: as is also No. 262, which occurs at Tremail, on the road to Davidstow, and which probably forms a continuation of one and the same stratum. At Trevivian is the same kind of slate (263.) as that above the limestone at Grylls; and which continues to Wilsey Down. The whole of the country, between St. Cleather church and that of Davidstow, consists of these two kinds of rocks. At Treliegh the slate (264, 265.) has the same characters: and is succeeded by rocks similar to those of Tresparret Downs; which continue through the parishes of Warbstow, Jacobstow, and Week St. Mary:—as is shewn by the following specimens; No. 266, from Wain House Corner, near Jacobstow; and No. 267, from Treskinnick Cross, near Poundstock. The rocky shores of Widemouth Bay are formed of the same kind of slate and compact rock, as at Crackington Cove; and in like manner they alternate with each other, the compact and more durable rock forming projecting ridges. The low shores of this bay are covered, for several feet in depth, with a fine shelly sand. A little farther north, at Bude, the sand-banks are of much greater extent; and very much resemble those at Hayle. A considerable traffic is carried on with this sand, the transport of which forms almost the only employ-

ment for the canal which runs thence to the neighbourhood of Launceston.

The little creeks of Norcot, Sandy Mouth, Duckpit and Stanbury, between Bude and Moorwinstow, are all frequented on account of this shelly sand. All the cliffs along this part of the coast are formed of rocks similar to those of Crackington: so that specimens from one of these places will be sufficient; and those of Stanbury Creek (268, 269, 270.) were selected, as occuring near Moorwinstow, the most northern part of Cornwall. Here, the cliffs are very interesting, exhibiting a fine example of the curvatures and contortions of rocks; and the strata are heaped on each other apparently in utter confusion, dipping towards every point of the compass, and at various degrees of inclination.

FROM MOORWINSTOW TO BREY HILL, NEAR BROWN-WILLY.

Returning southward, near the borders of Devonshire, the whole of this narrow northern part of Cornwall appears to be composed of rocks similar to those on the sea coast. The specimens were collected as follows:—No. 271, on the road from Stursdon to Kilkhampton; No. 272, between Stratton and Marham; No. 273, near Whitestone church; No. 274, at Tamarton; No. 275, about half way from the last place, on the road to Boyton; No. 276, at Boyton; and No. 277, at Lady-cross, a little north of Werrington. All of these are hard com-

pact rocks, with the exception of No. 275, which is a dark coloured slate from a deep trench by the road-side:—it is probable, however, that the latter rock occurs more frequently throughout this tract, and that it alternates with the others as on the sea-shore; but the reason of its not being so frequently exposed as the compact rock is owing to the excavations, from which these specimens were obtained, having been made on these compact rocks in order to procure a good stone for repairing the roads.

Near Yeolm Bridge, on the north west of Werrington Park, is a slate-quarry, which is extensively worked: this slate (278.) is different from any of those already described; it is of a dark colour, like No. 275, but is variegated with diagonal stripes of brown, which produces a good effect when the slate is polished: it is employed for chimney-pieces and other ornamental purposes. It has very much the appearance of the calcareous flag-stones of Devon; and on being thrown into diluted muriatic acid it effervesces for an instant, indicating the presence of carbonate of lime: this is also rendered probable by the position of this slate; for immediately on it rests a bed of compact limestone (279.) which is traversed by numerous veins of calcareous spar. These strata are exposed to view for about one hundred yards in length, and thirty feet in depth, so that they can be distinctly seen to dip N. N. W., at an inclination of 40°. In Greenough's Geological Map of England these rocks are laid down as a continuation of the series belonging to the Dartmoor granite.

At Egloskerry the rocks are massive, of an uniform blue colour (280.) and are varieties of hornblende-rock. On crossing the Attery river you enter on the downs; a continuous chain of hills which cross the county in the direction of east and west, from Launceston to the Atlantic Ocean. The rocks of this range, though somewhat different in appearance, are of the same nature, consisting of compact-felspar and hornblende united in various proportions; and of which the following are specimens:—No. 281, from St. Stephens Down, which is hard and very brittle, in consequence of the presence of quartz in grains, and very minute strings; No. 282, from the Race Down near Trewithick; No. 283, from Red Down; No. 284, from Tregear Down (not far from Tresmeere) it is in a decomposing state, cleaves readily into laminæ of a rhomboidal form; its strata dip N. N. E., at an angle of 20°., and are traversed by horizontal veins of quartz, many of which are hollow, and are divided into numerous compartments by thin septa of the same mineral, some perpendicular, and others variously inclined; and lastly No. 285, is from a block on Laneast Down.

These downs are very interesting in an economical, as well as in a geological point of view; for they contain extensive deposits of the ores of manganese. Many of these have been explored, and have been very productive: but as far as I could learn the remuneration to the *adventurers* must be inconsiderable, in consequence of the low price of this article, and the heavy expense of a long land-carriage over

a bad and hilly road. The mine of Letcott or Litcot, situated on the eastern border of Laneast Down, is particularly interesting; it has been worked for many years, and has been a profitable undertaking. The present workings are twenty fathoms deep, and subject to a considerable influx of water; but as the mine is on the side of a hill, it is easily *unwatered* by a pump worked by a water-wheel. The ore occurs in a bed, or *cross-course* of *capel*, which is about twelve fathoms in width, and runs north-east and south-west: and which (286, 287, 288.) consists, for the most part, of hard siliceous minerals, or rather of varieties of compact-felspar, in which silica predominates. On this bed the manganese-ore (289.) is arranged in veins and bunches: in the latter form it was originally discovered, not many feet below the surface; and in such a large body, that it was obtained at a very trifling cost. The firmness of the *capel* permitted the ore to be followed in all its ramifications, without needing support: and the result has been a large chasm, the irregular and indented sides of which indicate that this ore is of contemporaneous origin with the rock in which it is deposited.

On the north side of this *course*, next to the valley, the strata are formed of a greyish speckled slate (290.) like that of Hendraburnick: and on the other side the rock is hornblende-slate (291.) which is succeeded, a little farther south, by rocks similar to No. 247.

Crossing Laneast Down in a direct line to the granite, I did not observe any intermediate rock

in *situ;* though it can hardly be doubted, but that schistose rocks do exist in the valley between Laneast church and Brey.

Such are the rocks of the Eastern District; and, with the exception of the limestone of Crimble Point, and the red sandstone of Cawsand, all of these appear to belong either to the granite or the slate formation.

CHAP. II.

ON THE GEOLOGY OF THE CENTRAL DISTRICT OF CORNWALL.

THE boundaries of this District are readily defined by drawing a line from Wadebridge to Lostwithiel, so as to connect the Harbours of Padstow and Fowey; and, another line from the mouth of Falmouth Harbour through the Truro-river to the Gannel on the north coast: the intermediate space forms the Central District, and comprises nearly the whole of the Hundreds of Pyder and Powder. It is, therefore, much less than the Eastern one in superficial extent: but it is much more interesting to the geologist.

The central district contains only one patch of granite, the form and position of which will be

sooner comprehended by the Map, than by any description. The eastern portion of this granite is large-grained, crystalline, and occasionally porphyritic, like that of the eastern district; the western, abounds in shorl, and contains a peculiar granite which is extensively disintegrated, and which forms the characteristic feature of this district. It is, therefore, proposed to commence near St. Stephens, where this rock is very abundant.

About a mile north of this village the granite is entered on at a place called Step-aside; but the rock (292, 293.) here exposed is much *weathered.* Near Restowrick, however, about a mile farther north, the granite is of the same kind, and is in an unchanged state. It (294.) is composed of the usual minerals; —the felspar is white, with a light tint of yellow, and crystalline; the quartz is in large grains, white and semi-transparent; and the mica is of a light brown and resplendent, but is present in a less proportion than is common even in cornish granite. Near the last mentioned place a bed (295.) of more compact granite occurs, in which the mica is wanting, and its place is occupied by a dark coloured mineral, with a tinge of purple when viewed in certain positions. Between Step-aside and Restowrick, are several quarries of *china-stone,* and pits of *china-clay.* The *china-stone* (296.) is a kind of granite, the felspar of which has undergone a partial decomposition: it is carefully selected so as to be entirely free shorl; and requires no other preparation for the *market,* than to be broken into a size convenient

for carriage. This granite is of a peculiar nature: it does not contain any mica,* but numerous glossy scales of greenish yellow talc.

There are many quarries of *china-stone* now in *working*, and the remains of many more are scattered over the hills and downs. On inspecting any one of these, the cause of the failure of this *stone* is evident: it has arisen from the presence of shorl in various proportions, which renders it unfit for the potteries, and thus stops the quarry-man in the direction of the bed, and his labours are limited on the sides by the micaceous granite (297.) in which this *china-stone* is imbedded. It appears, therefore, that these beds of porcelainous granite are very numerous. I could not ascertain their bearings in every case; they were, however, very commonly from north to south, or rather east of north, and west of south. This rock is often traversed by large veins (298, 299.) which are composed of crystalline shorl, granular decomposing felspar, and tin-ore.

These *china-clay works* are not confined to the parish of St. Stephens: there are also many others in the parishes of St. Dennis and St. Austle; but those of St. Stephens appear to be of a superior quality.

The quantity of *china-clay* exported from these places is very considerable, exceeding 7,000 tons per annum: and when to this is added the amount of *china-stone*, which is about 5,000 tons more, the

* Dr. Thomson, in his account of Cornwall states that "in the St. Stephen's granite, near St. Austle, I could perceive no mica, and have reason to believe that the rock contains none." Annals of Philosophy. Vol. 2.

whole forms a very important branch of commerce. In estimating the value of these works to the community, it must also be remembered, that they are situated in bleak barren moors; thus affording employment and support to several hundred persons, where the impracticable soil would hardly maintain a single family

I subjoin a short account of the preparation of the *china-clay*, as no communication has hitherto been made to the Society on this subject.

CHINA-CLAY, OR PORCELAIN-EARTH. A spot being discovered where this substance abounds, the operation is commenced by removing the vegetable soil and substratum, called by the workmen the *overburden*, which varies in depth from about three to ten feet. The lowest part of the ground is then selected, in order to secure an outlet for the water used in washing the clay.

The *overburden* being removed, the clay is dug up in *stopes;* that is, in successive layers or courses, and each one being excavated to a greater extent than the one immediately below it, the *stopes* resemble a flight of irregular stairs. The depth of the *china-clay pits* is various, but it seldom exceeds twenty feet.

The clay (300.) when first raised has the appearance and consistence of mortar: it contains numerous grains of quartz, which are disseminated throughout in the same manner as in granite. In some parts the clay is stained of a rusty colour, from the presence of veins, and imbedded portions of shorl and quartz; these are called by the workmen *weed*, *caple* and *shell*, and are carefully separated. The clay is next conveyed to the floor of the washing place: and is then ready for the first operation of the process.

A heap of the clay being placed on an inclined platform, on which a little stream of water falls from the height of about six feet, the workman constantly moves it and turns it over with a *piggle* and shovel; by which means, the whole is gradually carried down into an oblong trench beneath, which is also inclined and which ends in a covered channel that leads to the *catch-pits* about to be described. In the trench the grains of quartz (301.) are deposited: but the other parts of the clay, in consequence of their greater levity, are carried away by the stream of water in a state of suspension.

This water is conducted into a series of pits; each of which is about eight feet long, four in breadth and in depth, and is lined on the sides and bottom with cut moorstone, laid in a water-proof cement. In these pits the porcelain-earth is gradually deposited:—in the first pit, the grosser particles collect; and being of a mixed nature, are always rejected at the end of each day's work, by an opening provided for that purpose, at the bottom of the pit. When the water has filled the first pit, it overflows into the second; and in like manner into the

A peculiar kind of granite (303.) is found in a quarry on the eastern side of St. Stephen's Beacon, it resembles that last mentioned, with the addition of minute grains of purple fluor spar disseminated throughout the mass.

The foregoing varieties of granite extend to the eastward, as far as Carclaze mine which is worked *open to day*, like an immense quarry. The upper part of this granite is also much decomposed, but beneath it gradually becomes more solid and perfect; it is traversed by innumerable *strings* and *bunches* of shorl, and of shorl-rock, which abound in tin-ore.

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third: and in these pits, particularly in the second, a deposit also takes place, which is often preserved, and is called by the workmen *mica*. The water still holding in suspension the finer and purer particles of porcelain-clay, next overflows into larger pits, called *ponds;* which are of the same depth as the first pits, but about three times as long and wide: here the clay is gradually deposited, and the clear supernatant water is from time to time discharged by plug-holes on one side of the pond. This process is continued until by successive accumulations the ponds are filled. At this stage the clay is in the state of a thick paste: and to complete the process it only remains to be consolidated by drying, and then it is fit for the market.

This, however, is a tedious operation in our damp climate, and is effected as follows.—The moist clay is removed in hand-barrows into the *pans*, which are constructed like the *pits* and *ponds*, but are much larger, being about forty feet long, fifteen wide, and a foot and half in depth. The above dimensions may not be quite correct, for I did not actually measure the pits; they are, however, very near the truth. When the *pans* are nearly filled, the clay is levelled, and is then allowed to remain undisturbed until it is nearly dry. The time required for this part of the process must depend in a great measure on the state of the weather, and the season of the year; because the *pans* are exposed to the air: during the winter at least eight months are necessary; whilst during the summer less than half the time is sufficient.

When the clay is in a fit state, it is cut into oblong masses, and carried to the drying-house;—an oblong shed, the sides of which are open wooden frames, constructed in the usual way for keeping out the rain, but admitting the free passage of the air. The clay thus dried is next scraped perfectly clean, and is then packed up into casks; and carried to one of the adjacent ports to be shipped for the potteries.

The porcelain-earth, (302.) thus prepared, is of a beautiful and uniform whiteness, and is perfectly smooth and soft to the touch.

These irregular veins are evidently contemporaneous with the granite; for they are so intimately blended together, that in order to obtain the ore both veins and rock require to be *stampt* and washed. This excavation is of considerable extent, exceeding several acres in superficial measurement, and more than a hundred feet in depth: it is a very picturesque object, and deserves the attention of all travellers who visit Cornwall.

About two miles north of Carclaze is another tin-mine, called Beam: it is situated in the granite, and was originally *quarried*, but is now regularly *mined*. The granite here is more compact and crystalline (304.) than the preceding:—felspar forms the greater part of the mass which is frequently porphyritic,—the quartz and mica, particularly the latter, are in less than the usual proportion. It is traversed by large *courses* which *underlie* towards the north about three feet in the fathom, and which are for the most part parallel to each other, having somewhat the appearance of stratification:—they vary in their composition, but in general the outer parts or the sides of the *courses* consist of (305.) disintegrated felspar, quartz, and that kind of yellowish talc already noticed, and the presence of which appears to be in some way connected with this extensive decomposition;—whilst their middle part is quartzose (306, 307.) united in various proportions with shorl, and intermixed with veins and bunches of tin-ore. This mineral, though more abundant in the *courses*, is not confined thereto; for the same occurs in the inter-

mediate layers of hard granite: these *courses* are, I believe, regarded by the miner as the *lodes*.

Having considered one characteristic feature of the granite of the central district, viz.—its great tendency to disintegration, another remains to be described; which, although of no commercial importance, is of considerable interest to the geologist, and, therefore, merits particular attention. I allude to the prevalence of shorl in this rock.

This mineral is not entirely wanting in any part of the granite: though in some of the hard crystalline varieties of this rock it is in very minute quantities. It is, however, generally plentiful in the quartz veins, either disseminated throughout in clusters of crystals and grains, or intimately combined therewith. Sometimes the shorl usurps the place of the mica altogether: and it appears to become gradually more abundant, as the confines of the granite are approached: as may be seen in the following examples.

The granite (308.) on the eastern side of St. Stephen's Beacon, and (309.) at Watch Hill, near St. Mewan's Beacon, is composed of two kinds of felspar (the one disintegrated, and the other in red porphyritic crystals), of grey quartz in large grains or rather nodules, and of shorl and talc in small prisms and scales. In this granite occur beds (310.) of a fine-grained variety of the same rock.

Near the hamlet of Step-aside (about a quarter of a mile westward) the granite (311.) consists of coarse-grained quartz, reddish felspar, and shorl;

the quartz is the prevailing mineral, and the felspar is prone to decay: this variety skirts the granitic group on this side, through Mill, Kernick, Borgotha, Jolly Mill, and St. Dennis. Like No. 309, it also contains beds (312.) which differ only in being of a finer grain. And near Beam mine, the country is formed of the same kind (313.) of granite.

The hills over these kinds of shorlaceous granite present an uniform scene of desolation: the soil (if such a name be applicable to any thing so sterile) is full of fragments, and indeed oftentimes consists entirely of shorl and quartz in the state of sharp angular gravel; the decomposed felspar having been washed away by the rain, the mechanical power of which is increased by the steepness of the hills, and the unretentive nature of the gravel.

Here and there a group of immense bowlders, or a pile of untransported blocks, alone disturb the sameness of the prospect. Felspar scarcely enters into the composition of these masses, they consist almost entirely of quartz and shorl: and to the comparatively indestructible nature of these minerals must be attributed their durability, the more frail rocks around them having been removed by the gradual action of the elements. Cattaquilter or Carliquoiter rock (314.) is of this description. All the kinds of shorl-rock do not occur in the same bed; but in order to illustrate this subject, I have selected specimens from distant localities, that they may be arranged side by side in the Cabinet.

One of the most characteristic examples of shorl-

rock (315, 316.) occurs at Roach; it is, however, situated without the boundaries of the granite. This celebrated Roach-Rock, so much frequented by the the curious, is equally inviting to the geologist: it crowns a somewhat conical eminence, the barren sides of which are strongly contrasted with an adjoining belt of cultivated land. The rock is formed of huge oblong masses, piled one upon another after the manner of the granite tors; to which externally it bears an exact resemblance. The constituents of this shorl-rock are both in distinct crystalline granules: and white quartz intermixed with the black shorl produces a good effect. Though this compound is hard and durable, it is very brittle, as might be expected from this property being common to both its constituents. The shorl-rock of Roach may be considered as the type of this rock, on account of the uniform and distinct manner in which its component parts are united: and compared with which, the other kinds may be regarded as coarse or fine-grained. The coarse-grained shorl-rock (317.) is found on the side of the hill above Jolly's Mill: its shorl is in prismatic crystals, and its quartz in crystalline grains, which are sometimes so large as to deserve the name of nodules; in some parts of this rock the shorl, and in others the quartz, predominates. This kind of shorl-rock is not often met with in this part of Cornwall, but is very common on the borders of the granite in the western district.

A fine-grained shorl-rock (318.) also occurs at Jolly's Mill, at Borgotha, and near Carclaze; it is

more compact and harder than the preceding: the same localities also furnish varieties of this rock, (319, 320.) in which the texture is still finer, and the particles so minute that the ingredients can only be distinguished from each other by their colour.

These gradually pass into what may be called compact shorl-rock, (321, 322.) in which the component parts can be no longer discerned; but which, there can be no doubt, is a compound of quartz and shorl. It forms very large layers, or courses, in the shorlaceous granites; and is indeed of common occurrence, as veins, in every kind of granite, and also in the adjoining schistose rocks. In veins, it often forms with the quartz alternating stripes, sometimes the one and sometimes the other prevailing; or the shorl is diffused throughout in such a minute proportion, that the quartz acquires thereby a dove blue colour. Compact shorl-rock is very various in colour according to the proportion of its ingredients: it sometimes is brownish black, but generally is of some intermediate tint between raven black and slate blue. One kind of this rock, which is a dark blue, might be mistaken for a fine-grained variety of greenstone; it may, however, be distinguished by the following characters:—it is very hard, but partaking of the brittleness of quartz, it is easily broken; it is not fusible; and its specific gravity is 2.75:—whereas the green stone is softer; it is very tough; is fusible; and its specific gravity is 2.90. I have been thus particular concerning the compact shorl-rock, because it is far more abundant

than any variety of this rock: and, though it could not have escaped the observation of those geologists who have visited Cornwall, yet its nature does not appear to have been duly appreciated.

Another interesting kind of shorl-rock forms St. Mewan's Beacon: which is about a mile and a half north of St. Austle, and is situated on the brow of a hill; like that of Roach, it has very much the appearance of granite, in which rock it occurs traversing it in the direction of north-west and south-east. Some of the blocks of this tor (323.) are composed of quartz with minute particles of a yellowish brown mineral interspersed throughout, the nature of which is not apparent: most of them, however, contain crystallized shorl in variable portions, (324, 325, 326.) but which never equal the quartz in which it is always imbedded; this basis of quartz is massive and crystalline with a bright vitreous lustre. On account of the prevalence of quartz in this compound, it may be called quartzose shorl-rock. It is a very beautiful stone, and calculated to produce a fine effect in ornamental architecture: it would, however, require to be sawn, (no easy task on account of its great hardness,) for its brittleness would render it unmangaeable either under the hammer or chisel. The great expense of working it, would of course forbid its general use; but cases may arise, as in public monuments, when the cost would be more than compensated by the beauty and imperishable nature of this rock.

To the foregoing varieties may be added those,

in which one or both of the component minerals occur in distinct imbedded patches, in a basis either of fine-grained or compact shorl-rock: but these may be regarded rather as sub-varieties: No. 327, from St. Stephen's Beacon, is a specimen of this description.

There yet remains another and very interesting form of this rock, which consist of alternating layers of black and white minerals, exhibiting the most complicated curves and contortions. This rock has been described, by the Rev. J. J. Conybeare,* as a compound of alternate layers of granular quartz and shorl: and such is his known accuracy that no doubt can be entertained of his correctness. The specimens that I have examined in various parts of the county all occur at or without the boundaries of the granite, and appear to be of a different nature:—the black are not formed of shorl, but of the compact shorl-rock, just described; and the white layers consist of quartz, which is generally more or less combined with felspar, producing a compound the properties of which vary according as one or other of the constituents prevails. The presence of the felspar is indicated by the rock becoming soft and argillaceous on *weathering:* the extent of which of course depends on the proportion of this mineral. This kind of shorl-rock is very abundant in the diluvium on Tregoss Moors, where the specimens Nos. 328, and 329, were obtained.

Such is a general outline of the granitic rocks of the Central District; but before quitting this part

* Annals of Philosophy. Vol. 5, p. 189. New Series.

of the country its extensive stream-works require to be noticed. These diluvial deposits of tin-ore are the most important in Cornwall, particularly those that are situated in the large tract of low moors between Roach and Luxullion:—the whole of this area is surrounded on all sides by hills, and resembles an immense shallow basin, which however has several narrow outlets, on the south, into St. Austle Bay. These stream-works vary in depth from ten to twenty feet:—turf and vegetable mould for a foot or two in depth form the uppermost layer; under which is a thick irregular bed of siliceous, or rather granitic, sand intermixed with pebbles of quartz, and of shorl-rock; this is succeeded by a layer of black peat containing the branches and trunks of trees, and other vegetable remains, it is about eighteen inches in thickness; and lastly beneath this vegetable stratum is the *tin-ground*, which consists of sand, gravel, pebbles and bowlders with tin-ore interspersed, all evidently derived from the neighbouring rocks. The ore is generally in the state of crystalline grains, and when prepared by washing, in the usual way, it resembles a coarse sand: this *stream-tin* is of very superior quality, yielding the purest metal which is known in the market under the name of *grain-tin*.

It may be here observed that the *streamers* sometimes find portions of the peat wanting, and they always pass over this ground; for they know by experience, that the search for ore would be labour in vain. "The old men," they say, "have been here before them:" and the disturbed state of the *over-*

burden shews that the ground has been already worked; and that this took place at a remote period, is rendered probable by the discovery of wooden shovels and other ancient implements, in similar situations in many parts of Cornwall.

On the southern coast of this district there are also several important *stream-works;* but these will be noticed in another place. In the above brief account I have not given any minute particulars; as this has been already done by Mr. Henwood, whose statements agree with my own observations.

From Hensborough to Bodmin.

Descending from the granite hills, near Hensborough, on the road to Roach, the valley is found to be barren, being covered with diluvial *debris*, in which are some *stream-works:* and in the rivulet there is a considerable accumulation of siliceous sand, derived from the neighbouring china-clay works.

It has been already stated that Roach-Rock is situated beyond the boundary of the granite; and that it is surrounded on all sides by cultivated fields, which are very fertile, except in the direction of the granite hills. Around Roach the soil is very deep: but wherever an open trench or pit afforded a view of the substratum, it was found to consist of a variety of slaty felspar-rock (330.) in a state of decomposition: the most perfect specimen was found in the valley on the eastern side of the Rock; it (331.) is a compound of granular felspar, with an

intimate, though very sparing, mixture of a dark coloured mineral, perhaps shorl or hornblende. This kind of rock often occurs in the vicinity of granite; and it prevails over the whole of the Tregoss Moors, as may be seen in the numerous *stream-works*. This rock is traversed by veins of quartz, containing various portions of shorl: and it is (332.) generally so much disintegrated that it is in the state of a firm clay, which retains the original slaty structure, separating, under the blow of the *pick*, into thick flakes. It is owing to this substratum of clay that the rain-water is retained at the surface in all the hollows of this moor. Immediately above this clay is the *tin-ground*;—a bed of pebbles, consisting of quartz and shorl, but for the most part of that variegated or agate-like variety of shorl-rock (328, 329.) already described, and which will be more particularly noticed. This diluvial deposit is seldom more than three or four feet in depth, and in no instance exceeds ten feet, at least to any extent.

The sterility of these moors must be ascribed to this deposit: for the swamps might be obviated by draining, as the situation is elevated. Several patches on these moors are, indeed, enclosed, and brought into tillage; such parts, however, are higher than the general surface of the moor, to which circumstance their superior fertility may be owing, the more elevated ground having been exempted from the diluvium that covers the lower levels.

Proceeding from these moors to Bodmin the same rocks continue, both on the right and left of the road,

as far as Lanivet hill: the side of which is covered with bowlders, and projecting masses of rocks (333.) which at a distance have very much the appearance of granite, but which on nearer inspection prove to be greenstone, or rather purple felspar-rock; and the hill itself is formed of the schistose variety (334, 335.) of the same kind of rock, as is shewn by the rubbish around the numerous shafts.

A little nearer Bodmin the slate (336.) becomes more fissile and granular; it is intermixed with a green crystalline mineral like chlorite: the upper and decomposed part of this slate (337.) is of a light grey, slightly tinted here and there with green. About one mile from Bodmin the slate (338.) is somewhat fibrous and more argillaceous than the last, resembling that on the borders of Baron Down: this rock is partially disintegrated to a great depth. Here also, on the road side, a deep pit has exposed an *elvan-course* (339.) which is composed of greenish yellow compact-felspar with disseminated grains of quartz; the upper part of this rock is decomposed (340.) into a kind of china-clay. The dip and bearings of this rock could not be ascertained; but without doubt it is of the same nature as those *elvans* which so commonly occur in the vicinity of granite. There is one remark that suggests itself on viewing these specimens; viz. the colour of the felspar in the unchanged rock, which seems to imply, that the felspar and the talc of the St. Stephen's granite are here united into one mineral substance.

At the turnpike the argillaceous slates commence,

which are so abundant around Bodmin, and which have been already described. The rock (341.) forming the Downs to the right of this road going to Wadebridge, appears only to differ in being more siliceous, like that of Baron Down.

FROM ST. DENNIS TO PERMISCEN BAY.

Returning to the granite at St. Dennis, and passing over the shorlaceous granite, in a northerly direction, there is a hill which bounds the Tregoss Moor on the western side, and gradually slopes down to the Indian Queens. On this hill is the Fat Work tin-mine, by the aid of which the subjacent rock (342, 343.) is found to resemble the zoned shorl-rock so common on the moor; only differing therefrom in being composed of compact-felspar, coloured by shorl, or some such mineral, producing parrallel stripes, which are often variously curved and contorted. This rock gradually passes into a dark blue slate (344.) which is not abundant on this spot, but in the valley it becomes the prevailing rock. On each side of the *main lode*, to the extent of six fathoms, the rock is in a decomposed state, gradually becoming softer as it approaches the lode, where it is reduced to a firm clay; which becomes harder by exposure to the air, breaks into laminæ and retains the waved and curved markings of the perfect rock, it (345.) is for the most part of a brick red colour; but sometimes it (346.) is white in consequence, perhaps, of its being free from shorl, for the red colour of the

preceding variety appears to be derived from the oxidation of the iron contained in this mineral. It is a curious, though not a singular fact, that the shorl, when mixed with quartz, resists the action of the elements; but conjoined with felspar, it is susceptible of decomposition; thus participating in the property of the mineral with which it is combined. It may also be observed that throughout this soft mass there are hard portions of the rock, which appear to owe their immunity from the common decay to their containing more quartz, resembling the diluvial pebbles on the moor.

From these facts I conclude that this rock is not a shorl-rock, but a compound of felspar, quartz and shorl, variously compounded and blended together; in short, that it consists of the same ingredients as the shorlaceous granite, which it immediately succeeds. This rock, therefore, (if this view of the subject be correct) unfolds a most important page in the book of nature, throwing additional light on the connection of the granitic and slate formations: in it we perceive all the contortions of the strata so characteristic of the latter: and from it, hints may be gathered whereby these phenomena may be explained. This topic, however, will be considered more fully hereafter in the last chapter.

The next circumstance which calls for attention, regarding this interesting mine, is the main lode; which is fifteen fathoms wide, runs east and west, and inclines a little to the north, but is nearly perpendicular. The tin-ore (347, 348, 349.) is of supe-

rior quality, and occurs within this lode in the form of innumerable short veins, often in layers or *floors*, which are sometimes arranged one above another: small veins of this ore are also frequently observed traversing the rock in various directions. Quartz and shorl accompany the tin-ore in the veins: and it may be noticed that in small cavities in the latter, portions of pure porcelain-earth are often found. The lode itself is a hard compact rock, (350, 351, 352.) consisting of an uniform dark coloured basis, containing innumerable small angular pieces of rock, like that in which it is imbedded. These imbedded portions resemble fragments: and if this be the case their angular forms shew that they have not been transported far from the parent rock. This is another instance of an apparently fragmentary lode: and though somewhat different in its nature, yet it belongs to the same class of facts, as those of St. Teath, Relistian, and others.

It must also be mentioned, that this main lode is intersected by numerous and regular veins of quartz, in the direction of north-west and south-east: these veins are seldom more than five fathoms asunder; they do not heave the main lode, nor do they appear to affect it in any respect whatever.

With regard to this mine, it only remains to notice a large angular piece of tin-ore* (352*a*.) which is curious on account of the position in which it was found; the flat side was in contact with the main lode, and the other parts were imbedded in the red

* Presented to the Society by the Captain, Mr. Thomas Treweeke.

decomposed rock, some of which still adheres to it. This tin-ore must either have been contemporaneous with the rock in which it occurs, or it must have sunk into the latter whilst in its present soft state: I incline to the former opinion; because, even on the supposition of veins having once been open fissures, the erect position of the walls of the lode indicate that the adjoining rock must have been in a firm and solid state to sustain the pressure arising in consequence of the intervening fissure of fifteen fathoms in width.

At the foot of this hill, to the north-east of Indian Queens, a manganese-mine was formerly worked: the mineral was found in a large *course*, running north-west, and south-east, composed of siliceous minerals; in some parts massive quartz prevails, in others petrosilex, iron flint, and hornstone passing into jasper: as in the following specimens, Nos. 353, 354, 355. The ore, as at Letcott, occurred in bunches, from the sides of which proceeded short thick veins in numerous ramifications. This mine was very prosperous for a time; but like all those, in which the ore occurs in bunches, it became suddenly poor, and was abandoned.

Castle-en-Dinas, and the adjacent hills which bound the Tregoss Moors on the north, appear from the fragments on their sides to be composed of the same kind of rock as the last, viz. of felspar, quartz, and shorl; either uniformly mixed and blended together, or arranged in alternate stripes and layers as at Fat-Work mine.

Approaching St. Columb Major the prevailing rock is a fine-grained and glossy slate (356.) which, at about ten or twenty feet beneath the surface, is of a fine blue colour; but the upper part of this rock (357.) is uniformly of a light colour, varying in shade from bluish and greyish white to yellowish white, with occasionally spots and stains of a rust colour. This property of changing from blue to white, during decomposition, appears to be very general throughout this part of the country, from Bodmin to Michael: and some importance is due to this circumstance, because it gives an insight into the composition of these rocks. When a slate has a blue colour, hornblende is frequently the colouring matter; but in that case the rocks become reddish brown on decomposition: which appears to indicate that hornblende is not contained in the blue slates under consideration. In many other parts of Cornwall blue rocks become white on disintegration; and in these chlorite or actynolite may often be detected as the colouring mineral.

On the north side of St. Columb is a quarry in a bluish slate (358.) very similar to the last: and about a mile farther north, near Trewan, is an imbedded mass of compact-felspar, (359.) in which may be observed small contemporaneous veins of a yellowish green mineral: if the rock were more exposed, this substance would most likely be exhibited in a more distinct form, and the composition of the adjacent slate might then be disclosed.

This kind of slate extends to Whitewater: ascend-

ing the hill from this place, a very barren tract of land is entered on, which extends east and west across the country to a considerable distance, under the names of Bogee and St. Breock Downs.

The sterility of this part of the county is attributable to two causes: first, to the nature of the subjacent rock which abounds in silica, both disseminated in fine particles imparting a granular texture, and also in the form of veins: and secondly, to its situation, which is elevated, and sloping steeply on all sides, so that the rain that falls thereon, not finding a passage through the compact rock beneath, flows through the sub-soil in streamlets, washing out its argillaceous portion which is thus transported into the valleys. No opportunity offered of seeing this rock in a perfect state: the specimens (360, 361, 362.) were obtained from shallow excavations; they shew, however, how greatly quartz predominates.

Passing this Down, slate (363.) is again entered on; it is similar to No. 358, but separates into much finer laminæ: this slate continues from St. Ervan to the vicinity of St. Merryn, where it is less schistose, dividing into slabs of about two inches in thickness. This rock resembles the slate of Endellion and St. Teath; and like it contains lodes of galena, sulphuret of antimony, and blende. The slate (364.) is from Wheal Friendship mine, immediately north of the church: here the main lode (365.) contains angular pieces of slate, as at St. Teath; and the cementing mineral is a crystalline quartz.

At Cataclew Point, near Trevose Head, is a very

crystalline rock; the greater part of it has a dark speckled appearance (366.) from the intermixture of white felspar and black hornblende; sometimes, however, it consists almost entirely of glassy felspar. The latter variety (367.) is very hard and tough; the former is not so refractory, and is frequently employed at Padstow, and in the neighbourhood, as a building material, under the name of Cataclew stone. This beautiful rock here forms an extensive bed; and it is also found near Gunver Head, and on each side of the mouth of Padstow Harbour, at Stepper and Pentire Points: indeed from the direction of all these places, it is probable that they belong to one and the same stratum.

In the cliff, on the north part of Permiscen Bay, limestone occurs interstratified with slate; and the alternations are repeated more than twenty times, as may be seen from a projecting cliff opposite. These strata reach to the water's edge: and the upper ones can be easily approached on the side of the cliff, where three strata of limestone, and two of slate, have been partially excavated. The uppermost bed of limestone (368.) is of a rust colour; it is in a decomposing state, and soils very much: the second (369.) is also altered in the same manner, but in a less degree: and the third (370.) is quite perfect; some of this has been burnt, and proved to be an excellent limestone. The slate (371.) between the two upper beds is calcareous, of a dark colour, with light brown stripes, like that at Yeolm Bridge, near Launceston. Between the limestone and the slate,

the rock (372.) is a calcareous schist, which is splintery, passing into lamellar, is harder than the slate, and decomposes into a white friable mass. These beds dip southward, at an angle of about 30°.

From Padstow to the Granite near St. Enoder.

In the neighbourhood of Harbour Cove, (a little creek on the western side of Padstow Harbour) the cliffs consist of the same red slate already noticed on the opposite shore: and the rocks from this place to Padstow, are similar to those of Rock House Ferry, on the other side; consisting of compact hornblende-rock, intermixed with beds of black limestone.

From Padstow to Little Petherick, the prevailing rock is slate, (373.) like that between St. Ervan and St. Merryn; but the former having been obtained from a quarry, is in a more perfect state. In this slate, near Dinas Cove, is a bed of limestone, (374.) like that of Rock-Ferry.

At Penquean is a quarry of roofing slate, the strata of which dip N. W., at an angle of 20°. This slate (375.) is of a blue colour without much lustre; it (376.) is rather soft, and separates easily into thin laminæ; in quality, however, it is not to be compared with that of Delabole. A few yards north of this quarry a thick bed of massive rock (377.) lies on the bank of the river: the basis of this stone is of an uniform grey colour, with a distinct white mineral interspersed throughout: it slightly effervesces with acid, and appears to be a compound of

compact-felspar and carbonate of lime. The upper part of this rock (378.) is decomposed, and the basis has become of a dark rust colour.

Rocks similar to those around St. Columb extend towards St. Enoder and Michael; between the latter place and the granite hills, the slate (379.) is a kind of chlorite-schist, in which, near Summercourt, a mine has been worked, but is now abandoned; the lode, consisting of quartz and chlorite, (380.) appears by the shafts to run east and west.

FROM MICHAEL TO NEW QUAY & ST. COLUMB MINOR.

From Michael over the Down to Newlyn, the rock (381.) exposed to view is a decomposing slate; but about midway the rubbish around a shaft affords this rock (382.) in a sound state: it is a blue slate with a striated structure; is soft and separates easily into laminæ, which are irregular, owing to the numerous short veins of quartz that traverse it: the quartz lodes contain argentiferous galena.

Similar slates continue north as far as the sea, and extend to the eastward around St. Columb Minor:—No. 383, is from Trevoal, and No. 384, from Gwills; they are light coloured and glossy, and dip north-west, at an angle of 30°.

The slate (385.) around New Quay, and on the shores of Fistrel Bay, are inclined to S. S. W., at an angle of about 40°: it is of a blue colour, soft and of a fibrous texture, very nearly resembling that of Newlyn Down: and in the cliffs it may be seen

decomposed to the depth of twenty or thirty feet, forming (386.) a very white glossy slate.

At New Quay the cliffs are full of large caverns, the roofs of which are lined with mosses and lichens: the greater part of these (387.) have been converted into calc-sinter, by the percolation of water holding carbonate of lime in solution. North of the signal station at New Quay, is a bed of shelly sandstone (388.) which has attained considerable hardness: and the same occurs in the cliffs around Fistrel Bay, forming an extensive horizontal bed which rests on the edges of the slate. This consolidated sand bears but a small proportion to that which is loose, and is only found near the cliffs at the lowest parts of the deposit. The sandstone of Fistrel (389.) does not contain so large a portion of shells as that of New Quay: and the lower part consists almost entirely of pebbles forming (390.) a kind of conglomerate, which has evidently been derived from the adjacent rocks.

These beds of pebbles and sand are situated just above high water-mark, and rest on the sloping ground at the upper part of the bay: but as the shore becomes more steep towards the points of the bay, the pebbles are wanting, and the sand rests immediately on the rock; and in like manner the sand also gradually disappears. Near the hills the pebbles and sand are covered by a stratum of *debris*, derived from the adjoining slate.

Dr. Paris,* in his account of these deposits, made the formation of sandstone almost the sole object

* Vol. 1. p. 1.

of his enquiry; but this production is of such frequent occurrence, that it is of less interest than the origin of the deposits themselves; and it may be here observed, that this recent sandstone is fast hastening to decay, being undermined and destroyed by the sea in a far more rapid ratio than that of its production; so that, at no distant period, there will not be a vestige of this formation.

"The sand* is supposed to have been originally brought from the sea by hurricanes, probably at a remote period;" and in confirmation thereof the Arundel papers are referred to: but it is more probable that it is the remains of an ancient beach, left dry by an alteration of the sea level, as will be more particularly shewn in the last chapter.

Dr. Paris* describes slaty limestone as occurring in this neighbourhood alternating with clay slate: and the Rev. Canon Rogers† in enumerating various localities of limestone, mentions Trevemper as one of them. These rocks, however, escaped my notice: but the nature of the surrounding slate indicates that they are near at hand; for in other parts of the country these slates are connected with limestone.

In a cliff quarry about half a mile north-east of New Quay, the rock (391.) is harder than the last, and breaks into thick slabs, the joints of which are much stained with oxide of iron: it resembles that kind of hornblende-slate, which at Padstow is associated with the black limestone.

I am indebted to Mr. Henwood for the following

* Vol 1. p. 4. † Idem 1. p. 7. ‡ Idem p. 116.

specimens from the neighbourhood of St. Columb Minor. The little islands at the entrance of Porth, are composed of calcareous schists and limestone: Nos. 391*a*, 391*b*, are from the south side of the inner island, and No. 391*c*, from the northern part of the same; Nos. 391*d*, 391*e*, 391*f*, 391*g*, are from the outer island. "About half a mile east of Porth an *elvan-course* (391*h*.) appears in the cliff, and passes inland near the parish church: its direction is about 30°. west of north, and east of south; its breadth forty feet, and dip E. at about 45°. to 50°.; the laminæ of the slate (391*i*,) in which it is imbedded, dip S.W., at 12°. to 20°.; and both the *elvan* and the slate, are traversed by a vein of quartz, which is two feet wide, and dips W." The *elvan* is much decomposed: it appears to be a felspar-porphyry, which is a very interesting circumstance on account of the vicinity of the calcareous rocks.

From Borgotha to Truro.

Proceeding from the granite hills, on the western extremity, shorlaceous granite and shorl-rock are left behind at Borgotha: and, from the appearance of the blocks scattered on the surface, the granular kind of shorl-rock here passes into a compact variety, like that of the Fat Work mine, near the Indian Queens: the extent of the latter cannot, however, be ascertained, as it is not exposed to view.

As Ladock is approached the last rock passes into (392.) hornblende-slate: and between this place and

Tresilian, near Trevirben, a bed of massive stone occurs, (393.) which slightly effervesces, and probably consists of compact-felspar, and carbonate of lime; the same kind of rock (394.) is also found west of Probus: both are traversed by veins of calcareous spar, and are thinly bespangled with scales of mica.

From Tresilian to Truro, a glossy slate (395.) prevails, it is of a fawn colour on the upper part of the strata, but below it is blue, as in No. 396; it contains veins of quartz; and also beds of compact rock (397.) into which it gradually passes, and which appears to possess a larger portion of quartz. These strata dip E. S. E., at an angle of 20°.

FROM ST. STEPHENS TO VERYAN.

On leaving the granite at Step-aside, about a mile north of St. Stephens, the slate formation is entered on: here the rock (398.) is similar to that of Roach; it is very prone to decomposition, and produces a fertile soil; it is in a more perfect state than the specimen from Roach, but still the nature of the dark mineral, in the felspar-base, is not evident.

The hill south of St. Stephens is composed of compact and slaty hornblende-rock: the former (399.) has not undergone much change; but the latter, (400.) though still possessing considerable tenacity, has become of a bright brick colour by the oxidation of the iron in the hornblende.

These rocks continue southward to Resugga Downs, which are covered with blocks of stone

(401.) which is very tough, and composed of compact-felspar, with imbedded grains of limpid quartz, and full of rust-coloured vesicles produced, perhaps, by the decay and removal of hornblende; these blocks probably belong to a *cross-course.*

South of this moor the country becomes very hilly; and at Trevanion mine, Crow Hill, the slate (402.) is blue, soft, and coarsely lamellar; and contains veins of quartz and chlorite, with galena, blende, and iron-pyrites.

At Trevillick, about a mile north of Grampound, the slate (403.) becomes harder, and more splintery; it is raised in thick slabs, affording a good building stone. The strata here, and at Grampound, dip W. N. W., at an angle of 35°.

On the west and south-west of Grampound, the slate (404.) is more regular and fissile: it is yellow and soft, not unlike the slate at St. Minver.

On the top of the first hill, on the road from Grampound to Truro, is an extensive bed of a coarse compact rock (405.) which has generally been considered as a characteristic example of greywacké: this granular rock appears to be composed of felspar, quartz, and a very minute portion of a dark coloured mineral: the quartz is the predominant constituent, and imparts its mechanical properties to this rock; but the presence of felspar is indicated by its argillaceous appearance on *weathering;* when also the nodules of quartz (406.) become more conspicuous.

At Tregoose, about a mile north west of the last place, is an extensive quarry, in a similar kind of

rock, (407.) though it is of rather a finer grain: it is traversed by quartz veins, and contains small irregular veins or strings of calc-spar. These strata are abundant in this part of the county, and extend east and west, and dip to the southward, alternating with coarse blue slates: and they bear a very strong resemblance to the compact rocks already described, between Buckapit Bridge and Tor Point.

From Cornelly to Tregoney the road lies over a fine-grained blue slate, (408.) very brittle and fissile, the laminæ of which have a smooth glossy surface; it is similar to the slate around Tresillian. This specimen was obtained at a quarry near the western end of Tregoney bridge. On the hill immediately south of the town, the rock (409.) is bluish, and contains minute shining scales, like mica, which substance appears to increase in quantity as you proceed southward; its laminæ are thick and irregular in the upper part of the stratum; it is yellowish white, (410.) softer and more regularly schistose: it is in a state of partial decomposition; it is imbedded in the same kind of slate as No. 408. A compact rock, (411.) similar to that at Grampound hill and Tregoose, occurs on the eastern side of the town.

A mile south of Tregoney, on the Veryan-road, near Hay, the slate (412.) differs only from the last in being somewhat striated, not unlike that of Cargreen Point, on the Tamar: it contains a stratum, which separates into thick plates, the cross fracture of which is granular: this rock (413.) is interspersed with minute micaceous scales;—No. 414, is the same

in a decayed state; and No. 415, from the same neighbourhood, is of a bright yellow colour, and more argillaceous than the last.

Near Trengrowse, about a mile farther south, the slate (416.) is of the same nature, dark blue, and bespangled with mica. This continues, wherever the rock is visible, to Crowan; where a massive rock (417.) occurs, which is but a modification of those between this place and Grampound, already described. Here also the hedges contain large blocks that are (418.) quartzose: they must have been derived somewhere from the adjoining land; for they are too large, where stone is plentiful on the spot, to have been brought from a distancc: it may, therefore, be presumed that the stratum, whence they were derived, is near at hand; and indeed the connection with No. 417, is so natural, and the transition, by an increase of silica, is so easy, that these two are probably part of the same *suite* of strata.

Still proceeding southward, on the ascent of the road, near Polcouta, layers of limestone (419.) protrude: they are very thin, and imbedded in (420.) a coarse blue slate. Both of these rocks are traversed by irregular thick veins (421.) of quartz, which are curiously fretted into irregular cavities, owing to the removal of calcareous spar, which the quartz contains in crystalline patches and veins: and it is worthy of remark, that though these minerals are so opposite in their characters, yet they are so blended at the point of union, that the eye cannot trace the line of demarcation; and indeed the quartz has a

peculiar opalescent lustre, which possibly may be derived from a minute portion of carbonate of lime entering into its composition. These strata of slate and limestone dip E. of S., at an angle of about 40°.

An account of the limestone of Veryan, by the Rev. Samuel Trist, has been already published in the Society's Transactions, and illustrated by a plate. This plate is, I think, inaccurate; because, if the limestone of Polcouta, of Veryan, and of Pendower beach, belonged to one and the same stratum, in the direction of its dip, the hill of Polcouta ought to have an elevation of about 5,000 feet above the level of the sea: for these strata are inclined at an angle of 40°.; and the distance between the extreme points is about a mile and a half. In the plate, the dip is drawn at 25°.: if it had been at 40°., the error would have been more evident. Having examined the strata on the sea-shore, I called on the Rev. S. Trist, and stated my objections as above; which he received with the greatest candour, and informed me that he had for some time past entertained similar doubts, but more important duties had prevented him from communicating the same to the Society. He also added, that he had altered his opinion concerning the nature of the numerous blocks of quartz-rock scattered over the southern part of the parish: and he obligingly accompanied me to a place near the farm-house of Carne, south of the Beacon, where these masses are most abundant, and where this rock is undoubtedly in *situ*, projecting near the crown of the hill, almost in contact with an immense

pile of detached masses, that lie immediately below. This stratum also dips east of south, at an angle of about 40°.: it (422, 423.) consists for the most part of quartz; and is precisely of the same nature as the rock noticed at Crowan. On its upper part, it becomes more lamellar, softer, and more argillaceous: and there is little doubt, that it ultimately passes into slate by the gradual increase of the aluminous mineral with which even the most massive parts are more or less blended.

To the eastward of this place, not far, I think, from Tregamenna, we visited a little quarry of massive rock which Mr. Trist called greenstone, on the authority of Mr. Tweedy, of Truro. The part of the rock exposed is somewhat changed, which increases the difficulty of determining its nature: it (424.) has a mottled appearance, being composed of a basis, which, like the neighbouring quartz-rock and limestone, is of a dark greyish colour, and of an imbedded white mineral in the form of angular spots, patches and layers: throughout the mass are interspersed cubes of iron-pyrites, the impressions of which, lined with ochreous matter, alone remain in those parts of the rock which are much decomposed. I did not visit Penare Point, but was informed by Mr. Trist, that it is formed of a similar kind of rock.

Under Gwendra, on the shore of Creek Stephen, numerous beds of limestone are exposed to view: it (425.) has the same characters as that of Padstow, and other places on the north coast: and it alternates with a blue slate, (426.) the laminæ of which

have a silky and somewhat striated surface, and in texture are irregular and a little curved: this slate resembles that of New Quay at Towan Bay; and also, like it, decomposes into a light coloured slate, No. 427. Between this slate and the limestone, calcareous schist (428.) occurs, through the medium of which the transition is effected.

About two or three hundred yards farther to the eastward, is a rock (429.) which appears to illustrate the composition of the limestone of this district. It is more crystalline, innumerable particles of calc-spar, and of a black mineral like hornblende, being diffused throughout a basis resembling No. 425, and which, most probably, consists of an intimate combination of these substances.

On the western side of these alternating beds of slate and limestone (430.) is a stratum of massive rock. It is situated below high water-mark, and by the action of the sea has been fretted into ridges, the polished surface of which, when wet, has a fragmentary appearance; it is of a dirty yellow, and soft, though tough under the hammer. It is evidently in a partial state of decomposition, having the same relation to the perfect rock, as the light coloured slate, No. 427, has to the blue slate, No. 426. As the unchanged massive rock is not here in sight, its nature is not obvious; but it appears to me to be the same kind of rock as No. 424, already described, as occurring near Penare Point.

Such are the interesting rocks in the vicinity of Veryan, and before proceeding farther I will make

a few more observations on their geological relations to each other. It has already been repeatedly remarked, that the massive rocks, on account of their more crystalline structure, and consequently the more distinct state of their component minerals, form the key to a knowledge of the slate-rocks in which they are imbedded: now, the compact rocks of Veryan are limestone, quartz-rock, and that kind of felspar-rock, No. 424, which may, perhaps, be considered as a variety of greenstone for want of a better name. All of these have one thing in common, viz.—a partial or uniform intermixture of a dark coloured mineral in various proportions; which mineral, on account of its intimate union with the respective bases of these rocks, is not apparent; but in the limestone, No. 429, (the only instance where I observed it even approach to a distinct form) it resembles hornblende. It happens in many parts of Cornwall, that the mineral, which for a considerable distance forms the imbedded or accessory part of the mass, becomes in some strata the predominant constituent; but here I in no case observed the hornblende (if this be the mineral) to attain to such preeminence, or indeed to form any more than the colouring matter of the rock. It may, however, be remarked that immediately north of the greenstone quarry, the land is very red; and there rocks, containing a larger proportion of this mineral, may possibly exist; for the soil is very similar to that derived from hornblende-rocks.

Each of these compact rocks gradually pass into

the adjoining slate, which partakes consequently of their respective nature: thus, near the limestone, the slate is calcareous; near the quartz-rock, it is hard, brittle, and siliceous; and near the greenstone, more felspathic than at a distance therefrom.

As regards their geological position, I am inclined to think that this greenstone, and the slate into which it passes, (but more particularly the latter, which is by far the more extensive of the two) constitute this district; and that the limestone and quartz-rock, with their respective varieties of slate, are subordinate thereto. Thus we have another instance of the occurrence of quartzose rocks in the limestone series: but they differ from those in the neighbourhood of Plymouth Harbour, in being more compact, and containing less hornblende;—the latter being granular, and resembling sandstone.

The rock (431.) at Dodman Point is a blue glossy and fissile slate, abounding in massive quartzose layers. From Portmellion to Mevagissey, the slate (432.) is similar to the last, and contains strata of a coarse lamellar rock, (433.) like No. 413.

FROM VERYAN TO ST. ANTHONY.

Proceeding westward, along the beach at the head of Gerrans Bay, we pass over an extensive bank of pebbles, which are almost entirely of quartz, or of this mineral variously spotted and striped with the substance of slate. The cliffs under Pendowa are formed of diluvial deposits of considerable thick-

ness, reposing horizontally on the slate which is visible here and there at the foot of the cliff, dipping towards the sea, at an angle of 35°. This horizontal deposit consists of layers of different substances, all of which gradually pass into each other: the inferior beds are consolidated into rocks, some of which are much harder than the slate on which they repose, even when this is an unchanged state. The two lowest strata are conglomerates, composed of the same kind of pebbles as cover the shore, intermixed with sand, and some scattered fragments of slate: one of these layers is ferruginous, and is very hard, not unlike pudding-stone; the other is comparatively soft, cemented, perhaps, solely by carbonate of lime. No. 434, is from the junction of these layers. The upper layers (435.) contain but a small portion of pebbles and fragments, which gradually diminish upwards, until the layers (436, 437.) consist entirely of sand: these are friable, and of a reddish brown colour; and the sand, of which they are composed, is not calcareous, it appears to consist of an intimate mixture of siliceous and argillaceous particles, interspersed with minute scales of mica. The argillaceous part gradually increases upwards, till it becomes a bed of clay: it is only the inferior and more siliceous beds that are lapidified.

The appearance of this stratified deposit is very curious and interesting. The layers are about eight or nine inches in thickness, and seldom exceed a foot: the whole lapidified part of the deposit is not more than ten or twelve feet. The sea, to the action

of which all these layers of diluvial rocks are occasionally exposed, has made considerable inroads, and as in the case of similar deposits on the shores of Mount's Bay and Fistral Bay, there is every prospect that the whole will be swept away at no very distant period. The layers of softer rock have suffered most from the waves, and as these are the upper ones, the whole exhibits the appearance of an irregular flight of stairs, the lowest of which are very broad, and in some parts, from the removal of the under layer, are pendant; but such is the tenacity of the rock, that they will bear the weight of the body. Portions of the conglomerate stand apart in advance from the cliff, surrounded by the pebbly beach, thus marking the ravages of the sea: other portions are connected in the upper part, in various arched and fantastic forms, affording a miniature representation of the cliffs and headlands, that are exposed to the full lash of the ocean.

It may be enquired,—what is the lapidifying process by which these deposits have been consolidated? This is not very apparent; but I think that it may be after this manner. The adjoining rocks, from which the *debris* have been derived, not only contain oxide of iron as a component part, but also abound in iron-pyrites; now, the ferruginous parts, being ponderous, would be deposited with the pebbles and sand in the lower portion of the diluvium, and would, in process of time, be converted into carbonate of iron: by which substance this bed of *detritus* appears to be agglutinated.

Leaving the sea-shore, and proceeding along the road towards Gerrans, the same kind of slate as No. 426, continues as far as Cargurrel, where a quarry by the road-side exhibits a light coloured and somewhat massive rock, (438.) which separates into thick coarse laminæ, thickly bespangled with mica: it resembles No. 414, at Hay, south of Tregoney.

Descending again to the sea-shore at Polcarnick, on the eastern side of Porthscatho Cove, the beach is covered with quartz-pebbles: the slate (439.) near the village of Porthscatho, is very much curved, and intersected by innumerable quartz-veins; it contains beds of a compact rock, (440.) which is polished by the sea, and has very much the appearance of the blue *elvans* near Penzance; it is equally as tough, but not so hard; it effervesces freely with acids, and contains veins of calcareous spar.

In the cliffs, eastward of this village, a mass of rock rises from the sea, at an angle of 45°., attaining a height of about twelve to twenty feet: above this is an immense mass of diluvium; from the bottom of which project horizontal layers of conglomerate and red sandstone, resembling Nos. 434, 437; the exposed portions of these rocks are very inconsiderable, perhaps they are of greater extent, as they are buried under the loose *debris* that has run down from the cliffs above.

At Porth, about a mile eastward of St. Anthony, is a slate (441.) similar to No. 408: but the most interesting circumstance here is a bed of sand and pebbles. When passing the farm-house of Porth,

I remarked on the side of a pit, near the hedge, several shells; and knowing the sea to be near at hand, I concluded that they had been derived from sand brought here for manure. A little farther on, however, I noticed more shells, and in a more ambiguous situation; and I therefore returned and examined into the matter more minutely, and found several sections round the farm-yard, which clearly proved that the hedge, and the cultivated soil adjoining, rested on a mass of diluvium, composed of regular beds of pebbles and sand; the former occupying the inferior part. Amongst the sand, the shells were in parallel layers, and in a perfect state; and in less than a quarter of an hour I found more than thirty different kinds of shells, principally univalves, and all common to the cornish shores. Porth is situated on a narrow neck of land, about a hundred yards from the sea on one side, and on the other about double this distance from the head of a little creek extending from St. Mawes' Harbour: and it may be about forty or fifty feet above the level of the sea; towards which the diluvial deposit gradually declines. The occurrence of shells in this sand-bank was to me very interesting, as I had never been able to detect any in the similar deposits of Mount's Bay. These shells prove that, whatever may have been the original source of the sand and pebbles, they have been deposited in the waters of the ocean:—but of this, more hereafter.

Near St. Anthony, on the side of the road from Porth, the rock is exposed, consisting of a blue slate,

(442.) which is fissile, but very brittle, exactly like No. 408, at Tregoney: and here it also contains (443.) a coarse laminated rock, with scales of mica, which is blue, in the lowest part of the quarry, but at the upper, is of a dirty yellow colour, (444.) as at Cargurrel: it is important to bear this in mind, as the partially changed rock has a very arenaceous appearance, and has been mistaken for a perfect rock.

At the landing-place of St. Anthony, the slate (445.) is curved and contorted, and much traversed with quartz-veins; near which the rock (446.) is less fissile, almost approaching to compact.

On the opposite side of the creek at St. Mawes, the slate (447.) is similar to No. 445:—and this continues to St. Just, where there is a stratum of slate, (448.) which is harder than the last, and more regularly fissile: a little farther north it (449.) is more granular and micaceous, All these strata dip southward, at an angle varying from 25°. to 35°.

From Grampound to Pentuan and Charlestown.

Returning to Grampound and proceeding towards St. Austle, about half-way to Hewas, blue slate (450.) juts out by the road-side; the upper layers of which are partially decomposed, and are of a light fawn colour, (451.) with waved markings.

At Hewas, the slate (452.) is similar to the last, but does not cleave into such regular laminæ: it decomposes into (453.) a red friable mass.

At Sticker, the slate (454.) is much more fissile,

and is used for roofing, though it affords but an inferior material.

On the side of the steep hill, about a mile from St. Austle, is a bed of compact rock (455.) resembling greenstone: it dips north, at about 40°.

Turning to the right, in a southerly direction, about half a mile from the St. Austle-road, is Polgooth, which is one of the oldest tin-mines in the county. It is worked in a blue slate (456.) which breaks into short thick angular pieces, the joints and seams of which are stained with a white clay, produced by decomposition of this rock. The specimen was procured at a depth of forty fathoms: but nearer the surface the slate (457.) is not so blue, and is stained by minute red veins. The slate next the *lodes* is of a darker colour, (458.) it is brittle and breaks so unevenly, that it is difficult to select a specimen; its surface is irregular, and covered with protuberances, occasioned by nodules of quartz inserted between the laminæ, as is visible on the cross fracture. The *lodes*, which are numerous, run north of east, and south of west: their matrix is chiefly quartz, which is full of cavities lined with crystals of the same mineral; and it is also intimately combined with the substance of the adjoining slate, enveloping insulated portions of the same, which are sometimes of considerable size, and are then termed by the miner *a horse of killas*. No. 459, shews the connection of the *lode* with the slate, which in this situation contains a larger portion of the colouring ingredient of the slate, sometimes

passing into hornblende, at others into chlorite. No. 460, is copper-ore from one of these *lodes:* and Nos. 461, 462, are specimens of the tin-ore, which is for the most part in minute prismatic crystals.

The slate in this mine is traversed by two great *elvan-courses:* the principal one is the *south elvan,* which is exposed on the side of the hill in a large quarry; it dips towards the north, at an angle of 70°., and is about fifty feet in thickness. The slate adjoining this *course* is much decomposed, somewhat like No. 457; it is felspathic, partaking of the nature of the *elvan.*

I was informed that both this *elvan* and the *lodes* are not regular in their course; but run in a zig-zag direction: that the *lodes,* in particular, scarcely exhibit any uniformity in their dip or size; being in some places several feet wide, and in others, dwindling to a mere thread; dipping generally towards the north, at various angles; and indeed, in some cases, being even reflected towards the south:—and lastly, that they are often divided into innumerable ramifications, both longitudinally and laterally. From all these circumstances, there can be little doubt that these *lodes* are contemporaneous with the rock in which they are imbedded: indeed the intimate manner in which the slate and *lodes* are blended together, as seen in the fragments brought to the surface, is in favour of this conclusion.

In composition the *south elvan* (463.) is similar to that of a fine-grained granite, consisting of a basis of granular felspar, throughout which small pellucid

grains of quartz are thickly interspersed; scales of brown mica, and small, though well defined, crystals of tourmaline are also present. Some parts of this *elvan* are porphyritic, and the crystals of felspar are well formed, attaining sometimes nearly an inch in length. No. 464, is from the upper part of the bed, and is partially decomposed. The *north elvan* does not dip quite so rapidly as the last, but in other respects it is similarly circumstanced. A small portion of it (465.) is exposed at the surface: it is a yellowish fine-grained compact felspar: very friable, and evidently in an altered state.

Where the road from Polgooth meets that of St. Austle, the rock is exposed on the side of the hill: it (466.) is schistose, and very different from that of Polgooth, resembling that about Tregoney and Grampound: its dip is S.E., at an angle of 40°. It contains a thick stratum of coarsely laminated rock, (467.) like No. 414, near Tregoney, and No. 443, at St. Anthony; but it is rather harder, owing to its being more siliceous: this is particularly so with No. 468, at Pentewan: the slate (469.) adjoining the latter partakes of the same nature.*

Ascending the hill from the latter place, by the road to Charlestown, the slate (470.) is similar to the last, but rather more fissile; its dip is with the fall of the hill, viz. N. W., at 25°. Before reaching the Black Head, near the edge of the cliff, is an old quarry which has been extensively worked as a building material, (under the name of Pentewan

* See Mr. Colenso's account of Pentewan Stream-work, p. 29.

stone) for which purpose it is well adapted; and, in appearance, it is equal to the best freestone. I did not visit the present workings, which I have since learnt are at the base of the cliff near the sea, which is more convenient for shipment. The Pentewan stone (471.) would be termed by the miners *an elvan;* indeed it does not much differ from the *south elvan* of Polgooth, from which it is two miles and a half distant: it consists of a basis of compact felspar, which has less of the yellow tint common to that of Polgooth, the quartz is also transparent, the mica silvery and in sparingly scattered minute scales. Its dip appeared to be N. E., at 45°.: but as the slate was not visible here, it is no easy matter to decide which of the parallel fissures, dividing the rocks into cuboidal masses, denotes the direction of the strata.

About a mile and a half from Pentewan, the slate (472.) is the same as the last, though it here dips N. E., at 25°. Turning to the right, and descending to the sea-shore, at Lower Porthpean, the slate (473.) approaches to that of Polgooth; it is of a dark blue colour, and somewhat silky, and breaks into thick laminæ: in the upper part of the cliffs it is decayed into a soft dirty coloured rock, which (474.) is of a bright red in some places, more particularly adjoining the quartz-veins that traverse the slate, where it (475.) soils like red chalk.

The next cove, going towards Charlestown, is that of Duporth; the southern part of which is composed of the same blue slate as No. 473. About the middle of it the slate beomes softer, and contains a

bed, (476, 477.) which is glossy and talcose, of a light mottled colour, and to the touch has the soapy feel of steatite: it easily cleaves into thin laminæ, both sides of which are parallel, but are raised into angular contortions. A little farther northward, a small promontory juts out from the cliff: it is formed of a massive rock, the lower part of which is finely polished by the action of the waves. When I saw the Rev. S. Trist, at Veryan, he informed me that at Duporth I should find serpentine: I am much indebted to him, for without this information, I might have passed this place, which is one of the most interesting in Cornwall. This rock, (478.) though soft, is very tough; it is not homogeneous, but has a mottled appearance, derived from the intermixture of dark and light coloured parts; the latter, which is greyish, with a very pale tint of green, is the most abundant ingredient, and occurs in the form of imbedded, irregular, but somewhat angular, portions, having all the characters of steatite; the dark part, or the basis, I take to be a compound of this steatite, and a variety of hornblende, or some such analogous mineral, the same as constitutes the colouring ingredient of the neighbouring blue slate. This rock, (479.) when polished by the sea, shews the manner in which its component parts are aggregated. It is traversed by numerous veins of asbestus, some of which are two or three inches in thickness: these for the most part are situated at the joints between the layers of the rock. This mineral (480, 481.) is of a greenish colour, and

consists of curved fibres that are not sufficiently coherent to admit of being separated. Like the serpentine of the Lizard, this rock is marked on its upper part by veins and patches, (482.) of a dark brown colour; these may be traced into the asbestus; it is probable, however, that this colour is not entirely derived from the asbestus, but from some substances accompanying it in the veins.

On the northern side of this projecting mass of rock, a parallel stratum occurs on the beach, and extends into the cliff above, in the state of a wet soft clay, (483.)which, in other respects is similar to the magnesian rock just described. The next stratum is firm and solid: it (484.) appears to differ from No. 478, in the constituent parts being intimately blended together. The next stratum (485.) is of a finer grain, and more uniform texture, and is lamellar: it is in a state of partial decomposition. This is succeeded by a blue slate (486.) similar to No. 473, at Porthpean: it (487.) is softer and whitish, where it comes into contact with the magnesian rock.

A few yards distant from this little head-land, near low water-mark, several blocks of stone lie scattered; it (488.) is a dark green coloured rock, homogeneous in its nature, more crystalline, and harder than No. 478; it better deserves the name of serpentine, than any of these rocks; and indeed, though not quite so black as that of Clicker Tor, yet it is not unlike it: this serpentine probably exists near this spot. The blue slate, No. 486, constitutes the cliffs between this place and Charlestown.

FROM CHARLESTOWN TO ST. AUSTLE, AND THE MINING DISTRICT.

At the back of Charlestown Pier the slate (489.) is blue like the last; and dips S. E., at about 20°.: and a similar kind of slate (490.) continues beyond this town, on the road to St. Austle. About half-way between these places, at an old copper-mine, the slate (491.) is still the same, containing quartz-veins (492.) much blended with chlorite.

In the neighbourhood of St. Austle the slate (493.) contains more hornblende, and is interstratified with (494.) compact hornblende-rock; and these continue north of St. Austle, as far as the granite at Carne Shute, a little above Trewoon, immediately under St. Mewan's Beacon; from which blocks of shorl-rock are scattered to a considerable distance in the valley below; there is no mistaking their source, this rock has such peculiar characters.

Returning to Charlestown, and proceeding through the mining district, the same kind of blue slate prevails, as that of Charlestown; so that it would be needless to describe the following specimens, farther than marking their locality. Nos. 495, 496, slate and *lode* of Wheal Apple Tree, immediately east of Charlestown. No. 497, about a quarter of a mile eastward of the last, near some old workings. Nos. 498, 499, from near the shafts of old Crinnis mine. No. 500, from the sea-shore, near the last. No. 501, from Wheal Pembroke; in this mine the *lodes* are composed for the most part of quartz, which is in

such a friable state, that even when crystallized, it can be crushed and crumbled by the pressure of the hand alone; this appears to be owing to the presence of porcelain-earth between the crystals and the joints of the same, derived most probably from the decomposition of felspar which originally occupied its place. Nos. 502, 503, 504, are specimens of these *lodes*, containing grey copper-ore, both compact and crystallized; the former sometimes occurring in large lumps, of which No. 505, is a specimen.

I examined the matrix of a great many *lodes* in this neighbourhood, and from the mode in which the slate and quartz are in all of them blended together, after the manner of that of Polgooth, I think that there can be no hesitation in pronouncing the *lodes* to be contemporaneous with the slate.

From Carn-Grey to Fowey.

Proceeding northward in the direction of Carclaze, on crossing the high-road between St. Austle and Lostwithiel, the soil becomes redder, indicating the presence of hornblende-rocks, which in a state of decomposition, (506.) jut out here and there, by the road-side, between this place and the granite: and imbedded in this occasionally appear portions, which are unchanged, (507.) owing to their being combined with silica, and intermixed with minute quartz-veins.

The granite first makes its appearance on the side of the hill, near an old building called Carclaze Blowing-house: it (508.) is rather fine-grained and shorl-

aceous; and is partially decomposed, the felspar being earthy. A little farther north, the granite (509.) is larger grained, and more perfect, and its quartz has considerable lustre. Here, near the boundaries, the granite contains large layers of shorl-rock, of which the following varieties predominate: —No. 510, abounding in shorl; No. 511, compact shorl-rock, with imbedded crystalline grains of quartz, imparting a grey colour; No. 512, alternating laminæ of the compact rock, and of quartz, the latter sometimes graduating into compact-felspar. Granite, (513, 514.) of the ordinary kind, occurs between the latter place and Trethurgy: and on the eastern side of Carn-Grey Rock, it (515.) is porphyritic.

From the village of Trethurgy the road runs north-east for about a mile, and then turns southward, through a valley which leads to St. Blazey. For more than a mile before reaching the latter place, the valley is covered with wood; the soil being deep, with diluvial fragments of granite and shorl-rock abundantly scattered throughout. From this circumstance it is difficult to ascertain where the junction with the slate is situated; but, from the appearance of the hills on each side of the valley, it cannot be far distant from St. Blazey. After crossing the bridge, at the latter village, the first rock that makes its appearance is at a little tunnel, cut through the projecting foot of the hill to convey water to feed the canal. It (516.) is a coarse lamellar rock, separating into thick somewhat rhomboidal layers, as is generally the case in the immediate

vicinity of granite. The surface of the fracture, in the direction of the laminæ, is thickly bespangled with filmy scales of mica; the substance of the slate, however, appears to be chiefly compact-felspar, slightly and partially coloured by the intermixture of hornblende, or some such mineral. Its layers dip S. E., at an angle of 30°. This slate very much resembles that which reclines on the side of Kit-Hill, near Callington: the latter, however, is much decomposed, whereas the former is more perfect.

Not far from this place are the great Lanescot mines, which comprising Fowey Consols, are more than one mile in length, and give employment to between twelve and fifteen hundred persons. These mines are almost entirely worked by water-machinery, which causes a very considerable saving. When I was there, a new machine for *jigging the ore* had been recently erected, and was then under trial, with every prospect of complete success. The principle on which it is constructed is very simple, and is creditable to the ingenuity of the inventor, Mr. Thomas Petherick, who is the manager of these well conducted mines. It was a bold undertaking to introduce a new mechanical power, which if successful would throw out of employment two-thirds of the girls and boys employed as *jiggers;* and at a time too, when riotous assemblies of the people for destroying machinery, distracted so many parts of the kingdom, and when even at this place itself, the miners had lately experienced considerable irritation on the subject of wages, and the exportation of corn.

The reason of their passiveness in this instance would be an interesting enquiry: it has been attributed to the superior intelligence of the Cornish Miner; but be this as it may, one thing is certain, that in Cornwall, where labour is so expensive, the only chance that the mines have of competing with those of other countries, is in the employment of more perfect machinery.

The slate (517.) on the north side of the mine is different from that in the neighbourhood of Charlestown: it is not of an uniform blue, but of a lighter colour, with dark blue spots; and it is slightly bespangled with mica: indeed it is nearly allied to No. 516, being, however, of a blue colour, softer and more fissile. This slate contains, and indeed alternates with, beds of a hard rock (518.) which has a fine-grained crystalline texture, breaks into irregular thick laminæ, but can scarcely be called schistose; its colour is variegated with stripes, and clouds of white and dark blue. At the mine this rock is called *flinty slate;* but it is a felspar-rock, partially coloured by hornblende, or some such mineral.

On the southern part of the mine, the slate (519.) becomes more uniform in its texture and composition; and at the shallow levels it (520.) is whitish and argillaceous. Near the surface, and also adjoining the *lodes*, the slate is soft and friable, or in the state of clay: I was likewise informed that even the hard felspar-rock, No. 518, is a soft *flucan* next the *lode;* a confirmation, if any be wanting, of its nature, for *flinty slate* is incapable of this change.

All these strata dip southward, at an angle varying from 30°. to 35°. The *lodes* run north-east and south-west, but are irregular in their *course*, and in their *underlie:* the largest ones are the most regular, but even these vary in size at different depths, and sometimes send off numerous ramifications; in short they much resemble those of Polgooth, and of the Crennis district; which, as already observed, seem to be of contemporaneous origin with the slate. The matrix of the *lode* (521.) is an intermixture of quartz and chlorite, or a mineral nearly approaching thereto: it gradually passes into the slate, both of the main rock, and of those portions that are enveloped in the *lode;* No. 522, is a part of the latter, through which are scattered minute veins, both of quartz and of crystalline flesh-coloured felspar: both of these, particularly the felspar, are associated with yellow copper-ore, which also occurs in the slate in small patches and veins. The *lodes* of yellow copper-ore are full of small cavities, lined with crystals of quartz, which are thickly covered (523.) by crystallized carbonate of iron: those of grey copper-ore (524.) are coated, and intermixed, as at Pembroke mine, with white clay, which is called by the miner *pryan:* and at the eastern part of the mine the *lodes* contain a considerable portion of blende (525.) associated with the yellow copper-ore.

Near Tywardreth the slate (526.) at the surface is somewhat changed and tinged with red: it resembles the slate No. 474, of Porthpean. At Pennick,

about a mile and a half from Fowey, the slate (527.) is of a deep red: and the country around the latter place consists of a similar kind of slate (528.) containing beds of a massive rock, (529.) which appears only to differ from the former in a larger portion of silica entering into its composition.

FROM ST. BLAZEY TO LOSTWITHIEL.

Returning to St. Blazey, the felspar-slate continues for about two miles from the bridge, on the road to Lostwithiel: then a tongue of granite intervenes, which stretches from Lanlivery across the road in the direction of Pelyn: this granite (530.) is like that of Carn-Grey. After passing the turnpike, near the place where this road joins that of Bodmin, the slate again occurs: the granite then takes a course parallel with the Bodmin-road, towards Helmintor.

About a mile before you come to Lostwithiel, and on the right-hand side of the road, is a large quarry; the stone of which (531.) is of the same nature as No. 516, at St. Blazey Bridge. Around Lostwithiel the rock, in view, is a slate in a state of decomposition, and for the most part tinged with red: it is like that which appears near the surface at Lanescot.

Ascending the hill from Lostwithiel, on the Bodmin-road, the slate (532.) is of a bright red colour. This specimen was obtained from an old quarry about half a mile from the town: with the exception of colour it appears to be of the same nature as Nos. 531, 516. A little farther on is a large *course*

of quartz and red iron-ore, (533, 534, 535, 536.) with a little manganese, the iron-ore forming the greater part of the mass: this *course* is close to the surface, and has been traced more than a mile, running nearly north and south; it is about twenty feet in thickness. A considerable quantity of this iron-ore has been exported within the two or three last years; it having been found not only very productive, but also of great advantage in facilitating the reduction of the clay iron-stone: by acting, no doubt, as a flux, its siliceous basis uniting with the alumina of the other ore; on the same principle as the copper-smelters have experienced the benefit of mixing those ores, the *matrices* of which are dissimilar. This *course* is of the same description as that near Indian Queens; in which manganese predominates in large bunches, and for which mineral it was solely worked: the remainder of this *lode* is probably as rich in iron as that of Lostwithiel; but its situation, requiring an expensive land-carriage, would preclude its being worked with equal advantage.

In concluding this chapter, it may be observed, that the Central differs, in many respects, from the Eastern District: its granite presents greater varieties, is not so elevated, and is more metalliferous; and its schistose rocks want the fine roofing slate of Delabole, the hornblendic limestone of Grylls, and the pyritous shales of Boscastle; but, on the other hand, they are rich in tin and copper-ores.

CHAP. III.

ON THE GEOLOGY OF THE CARNBREA DISTRICT OF CORNWALL.

Under this head is included that part of Cornwall which lies between the Central District, and a line drawn from St. Ives Bay, due south, through the creek of St. Erth, and terminating at Cuddan Point, in Mount's Bay. In extent the Carnbrea District is not equal to the Eastern District: but though inferior in this respect, its numerous mines and extensive sea-cliffs, afford more frequent opportunities for examining its structure; and its serpentine, at the Lizard, is an object of peculiar interest.

From Carn-Marth, near Redruth, to St. Agnes: and thence to Cligga Point.

The granite approaches very near to the eastern side of Redruth; and one branch of it stretches out from the main mass, and crosses the Truro-road, near the turnpike; but soon declines rapidly towards the north, near Cardrew copper-mine. This rock (537.) is large-grained and crystalline; and of that kind which predominates in the eastern district, and

which indeed is common to each of the granitic patches, and may, therefore, be regarded as the type of cornish granite.

On the upper part of Cardrew mine, the slate (538.) is whitish, soft, and evidently in a state of disintegration. The perfect rock (539.) is dark blue, hard and brittle, abounding with minute shining scales, arranged parallel with the laminæ of the rock; and which appear to be mica, or a mineral of a similar nature. This thick lamellar slate, as will be seen in the sequel, abounds near the junction of the granite and the slate.

The *lodes* of Cardrew mine run nearly east and west, *underlying* north: they are (540.) composed chiefly of quartz blended with earthy and crystalline chlorite; throughout which the copper-ore is scattered in strings and bunches. Between the *lodes and the country* (and also in detached portions included in the *lode* itself,) the rock is more slaty, (541.) resembling chlorite-schist; and in many places this is so penetrated, and intersected by quartz, that it (542.) has the appearance of fragments cemented by quartz. The schist passes into the rock, No. 539, by becoming more felspathic. This mine abounds in *elvans*; and, if I am rightly informed, they have similar bearings to the *lodes:* the intimate connection of these with the *country* is evident on inspecting the fragments at the surface of the mine. The slate (543.) adjoining the *elvan* is harder than No. 539, and intermixed with irregular strings and layers of quartz and of compact-felspar: and, in like manner, the

between them a deep and narrow *gulley*, through which a little mill-stream runs. On the St. Agnes side, a little way up the hill, is Wheal Charlotte mine, not now working: the rubbish at the shaft's mouth, with the exception of the fragments of the quartz-*lodes*, is fast crumbling into a whitish clay; the most perfect piece of rock, that I could obtain, is (557.) white, obscurely mottled with grey, it is massive and rather hard, and is evidently derived from a bed of compact-felspar. It is probable that the adjoining ravine has been excavated in this rock in consequence of its decaying more rapidly than the slate.

Along the north-west side of St. Agnes Beacon, the slate (558.) prevails, but is seldom met with in a perfect state: it has the appearance of a coarse granular felspar-slate. The beacon slopes rapidly, but gradually, down to this point; and thence northward to the sea, the ground is more level than is usual in Cornwall. At the foot of the beacon is Wheal Coates tin-mine, situated in an *elvan*, a felspar-porphyry, the base of which is granular: some parts of it (559.) contain large crystals of felspar, and coarse transparent grains of quartz, with a few minute scales of mica; and others (560.) resemble granite: as is of very common occurrence in the centre of extensive beds of felspar-porphyries. The two kinds, Nos. 559, 560, are said to alternate; the former is softer than the latter, on account of its being extensively decomposed, forming on a small scale a bed (560*a*.) of china-clay, which is of a bad quality, being more or less stained by metallic sub-

stances: it is employed as a *coating* for the bottom of furnaces. This *elvan* is of considerable extent, and may be seen following the course of the hollow which runs westward towards the sea for nearly a mile, and dips northward.

The miners are of opinion, that this *elvan-course* is a continuation of that at Cligga Point: but I could not satisfy myself that this statement is correct; for on referring to the map it will be seen that the *elvan* ought to traverse Wheal Pye mine, in which, however, it has not been detected.

On ascending the beacon the side of the hill is covered with fragments of decayed slate, and of quartz. The former (561.) is stained of a rust-colour at the joints, and thickly spotted with the same on a whitish ground;—it resembles slaty felspar. The upper part of this hill is formed of (562.) a dark brown rock which is fine-grained, compact, and very tough. The summit of the beacon is a large mound of loose stones, and is apparently the work of man. About twenty feet below this on the southern side the rock (563.) projects, evidently *underlying* northward, at about 40°. Descending towards the northeast, the same reddish slate as No. 561, is scattered over the surface; and the fragments, at Wheal Pye mine, exhibit the rocks, which form the hill of the beacon, in a perfect state: No. 564, is a light blue slate, with dark coloured crystalline spots, which possibly consist of the colouring mineral, but its nature is not apparent; No. 565, similar to the last, but more compact and covered with minute shining

specks; No. 566, a hard massive stone of a light blue colour and uniform texture, which alternates with the slate; No. 567, is a silky blue slate with minute veins of silvery talc: all of these appear to consist chiefly of compact-felspar, combined with variable proportions of silica, such as is frequently met with in the rocks near granite.

The whole of this neighbourhood is very interesting; but there is no part of it so curious, or so difficult to account for, as the various diluvial deposits on the northern side of the beacon: these consist of alternating beds of sand and clay, and are situated three hundred feet above the level of the sea, which is not far distant. These deposits occur near the base of the beacon where the ascent becomes highly inclined and continuous. They have been worked at several places, and judging from the situation of these pits, they are arranged around the foot of the hill in a semi-circular form. In order to select one of these excavations for description, I will take that which lies due north of the beacon. Immediately beneath the scanty vegetable soil, is a layer, varying from one to two feet in thickness, of loose earth, containing fragments of rocks similar to those in the adjacent hill: and indeed this forms the subsoil from the side of the beacon to the cliff, becoming deeper as it approaches the latter. Beneath the sub-soil is a bed of fine siliceous sand, (568.) ten feet in depth: this sand is of a light yellow colour, and consists of two kinds; the one, pure white, and transparent; the other, yellow, and semi-opaque:

it contains some minute particles of black shorl, but it appears to be quite free from aluminous and calcareous earths, and from organic remains.

This layer rests on a dark ochreous coloured sand (569.) of about two feet in depth; when first raised it is, in a slight degree, plastic, and on drying retains the form given it, but crumbles down on the least pressure, or when thrown into water: when examined through the lens, it is found to have the same composition as the last, differing only in a minute quantity of ochreous clay being interposed between its particles. It is possible that both these beds of sand were of the same origin; the ferruginous clay-like matter having been subsequently carried to the lower part of the stratum by the percolation of rain-water. Under this sand is a stratum of blue clay (570.) about a foot in thickness. It is very tough and adhesive, and so firm that it is cut with a broad chisel into square lumps; when dry it is of a light chocolate colour, mottled with irregular black markings; it has an oily rancid smell, like putty, which is not increased by being breathed on, nor does it emit an argillaceous odour: it is soft and greasy to the touch, and readily takes a polish; it imbibes moisture greedily, adhering strongly to the tongue; and when thrown into water it swells and falls into a soft paste; when calcined it becomes light coloured, and loses its rancid odour. The peculiar properties of this clay appear to be derived from a strong impregnation of animal matter.

Immediately beneath the last is another bed of

clay (571.) three feet in thickness, called by the workmen furnace clay: it is whitish and plastic, but falls into pieces on drying, which are easily reduced to an impalpable powder between the fingers. It emits a strong argillaceous odour when breathed on. Both these layers of clay appear to pass gradually into each other at the point of contact; and when the former is divested of its animal matter, it resembles the latter.

Below this clay is a bed of sand, seven feet in depth: it (572.) differs only from the upper siliceous sand in being nearly of a pure white. Lastly, this sand rests on a loose rubbly layer which is of variable thickness, and is similar to the subsoil; this *detritus* is said to repose on the solid rock.

It would be tedious to describe all these pits, suffice it to say, that their contents vary, both in the relative thickness of their beds, and in their number; for in some the intermediate stratum of clay is wanting. It struck me as curious, that at the two principal pits, in which clay was present, a ridge intervened between the hill and these deposits; indeed this is, in some measure, the case around this side of the beacon, but in these places it is particularly prominent. On this ridge there is only a shallow fragmentary layer over the solid rock; and as it is only about fifty to one hundred feet removed from the pits, the ground here has the form of a trough or basin. Such is a brief account of this interesting spot; it would be sufficiently puzzling to offer a solution of it, even if it were situated near

the present level of the sea; but at an elevation of three hundred feet above the sea, we must call in the aid of such an elevating power, which the other cornish phenomena do not seem to require.

In an economical point of view, these beds are important: the tough clay is used in the mines for various purposes, and is exported: and the yellow and white sands are extensively employed in the composition of stuccoes, for which purpose they are of very superior quality.

From St. Agnes to Trevaunance Quay, the same slate, (573.) as at Wheal Pie, prevails: and in it are worked several extensive mines: it may, however, be remarked that the matrix of the *lodes* (574.) consists chiefly of quartz and shorl, or of an intimate mixture of these minerals, forming what has been elsewhere termed compact shorl-rock; a substance exceedingly common to *lodes* in or near the granite. Along the sea-shore (eastward) the cliffs are in a very ruinous state; the slate decays rapidly, falls down in great masses, and is soon dispersed when once within the action of the waves: but the harder and more siliceous (575.) rocks, (which alternate with the slate, and which are intimately united with, and intersected by, quartz) lie piled on each other in large rounded masses; rendering the shore very rugged and difficult to pass over. Here, a large and elevated pile of rocks, which at one time evidently formed a projecting part of the cliff, is now insulated: thus shewing the more durable nature of the massive rock of which it is composed: both here, and

and on the adjacent rocks, the polished surface is striped with whitish and dark blue bands; the alternating laminæ, varying in composition; as if the blue colouring matter had not been equally diffused. This is of very frequent occurrence in Cornwall, more particularly in those rocks in which compact-felspar abounds; but this appearance being only exhibited on the edges of the laminæ, it is not easy to obtain a hand specimen; in consequence of the cross fracture requiring such a blow, as separates all the laminæ from each other.

Proceeding along the cliff, from each projecting head-land, the upper part of the rocks is seen to be in a state of decomposition, as shewn by their bright red colour; but it is dangerous to approach too near the edge of the cliff, for even the weight of the body might detach large masses. Many examples occur here of the encroachment of the sea on the land, although its attacks are directed against perpendicular rocks, two or three hundred feet in height In some instances the portions of cliff detached are very large: I measured one mass which was divided from the main land by a continuous chasm, more than a foot in width, and found it to average thirty feet in thickness, and more than two hundred feet in length; if to this be added the height of the cliff, what a rapid career of destruction is here indicated. This destructive process appears to be effected thus;—the laminæ of the slate dip from the sea southward, and are traversed at certain distances by perpendicular joints, which become

more developed during the progress of decomposition, so as to exhibit distinct seams: the cohesion of the rock being thus destroyed above, and the base of the cliff being at the same time undermined by the action of the waves, the layer of rock cannot support its own weight; it separates more and more at the top of the cliff, till at last it comes without its centre of gravity, and is precipitated into the sea.

On the side of the cliff, leading from Wheal Prudence mine down to the sea, I obtained the following specimens:—No. 576, a slate of a deep red, and much disintegrated; Nos. 577, 578, the same of a bright salmon colour, silky lustre, and its cohesion not sensibly impaired; No. 579, slate which is not quite perfect, but in which the red colour has nearly disappeared; No. 580, 581, the perfect rock, a blue slate, of a more homogeneous texture than that around St. Agnes.

Along these cliffs irregular beds of a granitic *elvan* may be seen traversing the slate: and amongst the breakers the same kind of rock may also be easily distinguished. A little beyond Wheal Prudence mine, at Hanover Cove, this stone is extensively quarried: there are several kinds lying side by side, in distinct layers of considerable thickness, and which dip north, at an angle of about 65°. Some of these are softer than others, as at Wheal Coates, near St. Agnes Beacon, in consequence of their being more disintegrated; and have been deeply excavated by the sea, leaving the harder kinds projecting in thick tabular masses; which for awhile resist the

destructive action of the elements, but which, as the ponderous ruins at their base, and their own shattered and serrated appearance indicate, must soon succumb to the incessant attacks to which they are subjected. I have seen no part of the sea-coast of Cornwall, where the destructive influence of the waves is so well illustrated.

These *elvans* are felspar-porphyries, consisting of a base of coarse granular felspar, with imbedded crystalline felspar, granules of quartz, minute scales of mica, and, not unfrequently, crystals of shorl. They exhibit the following varieties:—an uniform mixture (582.) of a dirty grey colour, called by the quarrymen *blue elvan;* lighter coloured (583.) than the last, containing white crystalline felspar; it works well like free-stone, but does not look as if it would bear exposure to the weather; a much harder rock (584.) with flesh-coloured felspar and shorl, in radiated groups of crystals; Nos. 585, 586, are in a decomposed state, the former quite white and apparently derived from a rock similar to No. 583, the latter full of irregular cavities stained with ochre, it has been used for lining furnaces. The slate (587.) adjoining these *elvans* consists for the most part of compact-felspar, with dark coloured spots, which are more distinct than in the slate of Wheal Coates, resembling more that at Roach, and St. Stephens; still the nature of the mineral that forms these spots is not evident. Nearer to Cligga Point, this slate contains beds of compact-felspar, (588.) the same as that at Wheal Charlotte; and like it also, it is exten-

sively decomposed: some of the harder parts (589.) have the dark coloured curved and contorted markings, so common in the rocks of St. Dennis, near Indian Queens: the dark parts owe their colour, I think, to an intimate union with shorl.

These various beds of *elvan* run nearly east and west, in the direction of Wheal Leisure mine: in the southern part of which, it is said to have been lately discovered. At Cligga Point these felspar-rocks are succeeded by a large mass (590, 591, 592.) of granite; that is, of a crystalline rock, composed of felspar, quartz, and mica, like the granite of the central groups: it also contains (593, 594, 595.) large porphyritic crystals of felspar, both red and white. At the southern part of the promontory of Cligga, is situated the old workings of the Great St. George mine: the rubbish around its shafts only exhibit the matrix of the *lode*, which consists of quartz, and a dark coloured compact substance, (596.) probably a compound of quartz and chlorite. At a shaft, about half a mile beyond the southern extremity of this mine, slate (597.) again occurs; and is exactly the same as that in the cliffs near Wheal Prudence: and indeed from its position it may be a continuation of the same stratum, lying south of the great *elvan-courses*. At the present workings of the Great St. George, near Wheal Leisure mine, the slate (598, 599.) is a spotted felspar, like that of the mines near St. Agnes: it is also traversed by (600.) a similar compact rock; but it does not contain any *elvans*, like those of Cligga.

FROM ST. AGNES TO CHASEWATER AND ST. DAY.

The southern side of St. Agnes Beacon is more precipitous than any other; and is rugged from several projecting ledges of rock, which is of that massive kind already described. For two miles southward, the rocks are very similar to those of Wheal Pie and Great St. George, as may be seen in the specimens (601, 602.) from Prince Royal mine, near Mount Hawke. Crossing Prince's Common, a most desolate scene meets the eye; the surface is covered with small fragments of red decomposing slate, largely intermixed with pieces of quartz; the uniformity of this desert (which extends for many miles to the right and left) is only broken by the numerous heaps of rubbish, the remains of former mining operations. The fragments of rocks, thus exposed, (603.) are of a bright red; and are derived from a slate similar to that which succeeds the felspar-rocks north of Cardrew.

Descending into a little valley at Blackwater, slate and compact rock (604, 605.) present themselves in a section afforded by a ravine. In this valley cultivated fields and a few trees gladden the eye; but this *oasis* is of little extent; for a steep ascent leads again to the common, which extends as far as Chasewater, over rocks (606, 607.) of the same character as No. 603. At Wheal Busy mine, the perfect slate (608.) may be obtained; it is of a dark blue, and precisely the same as No. 550, near Cardrew. The *lodes* (609.) here consist principally of

quartz, and of that coloured substance (*capel* of the miner) which appears to be an intimate union of quartz with a portion of the slate; and which is of very frequent occurrence in the metalliferous veins of this county. I omitted to bring away specimens of the *elvans:* those that I saw were of two kinds; the one, a granular compact-felspar, with imbedded granules of quartz, and *spicula* of a dark mineral like shorl; and the other, a dark coloured and very hard substance, almost entirely siliceous, and containing disseminated yellow copper-ore. In the collection of *elvans* presented to the Society by Mr. Carne, there are specimens of both these, under the names of *white and black elvans,* and also of a third kind called *red elvan.*

A little south of Chasewater, at Creag Braws, a *course of elvan* has been extensively quarried in the direction of the bed: it runs nearly east and west, and dips northward, at about 40°., as is shewn about the middle of the quarry, where the *elvan* is seen in contact with the slate, which is red, and much disintegrated. This *elvan* is a felspar-porphyry, varying, as usual, in different parts of the bed: some of its layers (699*a*.) have a basis of grey compact-felspar, containing white decomposing felspar, which is rarely in distinct crystals: the greater part (610.) of this *elvan,* however, has only imbedded granules of quartz, and numerous crystalline groups of a dark mineral, which decomposes into ochreous spots. The upper part of this *elvan* (611, 612.) has acquired a yellow colour, and is completely disintegrated.

That part of Poldice mine, which is entered on from Chasewater, is situated in a slate similar to that last noticed. Here, as at most of the large mines, it is not easy to see, at the surface, perfect specimens of the rocks; for even, where an *air-shaft* has been recently sunk, the fragments of the *country* are soon buried beneath the fragments of the *lodes*. The only heaps of slate (613.) that I saw here, were in a state of disintegration, and of a dark red colour; but even in this state it is evidently different from that around Chasewater, being full of dark coloured spots resembling that of Cligga, and other places adjacent to the granite. That part of the mine, next to St. Day, is in another kind of rock, compact-felspar, which (614.) is like that at Wheal Coates, and is abundantly intermixed with granitic *elvans*. A hard and very tough rock, of a purplish colour, (615.) immediately succeeds the last; it breaks into thick laminæ, the surface of which is copiously studded with minute shining particles. It appears to be a variety of compact-felspar, laminated by minute scales of mica, or some such mineral. Some geologists have considered this rock to be a species of gneiss; it does indeed bear the same relation to this rock, as the slate of St. Breward does to mica-slate: it is, however, a rock *sui generis*, and of common occurrence next the granite; and, therefore, deserves a peculiar name. It will be soon noticed again in a very interesting situation. This rock is in contact with a very hard porphyry, (616.) composed of large crystals of felspar, contained in a basis of very

quartzose compact-felspar: in part of this bed (617.) the felspar is of a bright flesh-colour. The *lodes* here consist principally of quartz and dark chlorite.

Between the last place and St. Day, the main mass of granite occurs; and this rock, (618.) which is of the common crystalline kind, extends nearly to Redruth, rising to a considerable elevation in the hill of Carn-Marth.

From St. Day to Redruth and Portreath.

Passing over the hills from St. Day, to the road which leads from Redruth to Penryn, the slate near Carbis, is found to run up a considerable distance into the valley between Carnbrea and the opposite hills: thus forming a large *bay* in the granite, as shewn in the map. The slate at Wheal Buller mine (619, 620.) is the same as that of Poldice, adjoining St. Day. The granite (621.) in this part of the county, is not very prone to decomposition: the large masses and bowlders on the side of the hills are decayed externally, and are discoloured to the depth of a foot or two; but the cohesion of its crystalline constituents is not much impaired.

A little north of Redruth, on the road to Portreath, a ridge of massive rock, (622.) apparently a compound of compact-felspar and hornblende, projects above the soil: it runs north-east and south-west. Tolgus mine is situated in a thick lamellar blue slate, (623.) which disintegrates into (624.) a white argillaceous substance, indicating the presence

of felspar. About a quarter of a mile farther north, the slate, at the mouth of the shaft, is dark blue, (625.) and similar to No. 608, near Wheal Busy, and No. 550, near Cardrew.

Drawing near to Portreath, the form of the country, and the nature of the rock, are both changed: the hills approach each other in a precipitous and rounded form, giving rise to the narrow valleys which terminate on the sea-shore; they are too steep for cultivation, but are well covered with coppice-wood. The rocks, about half a mile from Portreath, resemble those around Tregoney and St. Anthony; consisting of blue glossy slate, and a coarse lamellar micaceous rock. These rocks extend to the sea-shore; and exhibit the following specimens:—No. 626, slate, and No. 627, lamellar rock, both from the side of the hill about a quarter of a mile from Portreath; Nos. 628, 629, the same as the last, from the cliffs, much changed; and No. 630, slate also from the cliffs, more perfect than No. 626.

The numerous sections in the cliffs, and the large detached masses about gun-shot from the shore, distinctly shew how the layers of the slate rise and fall in conformity to the surface of the hills: so that in one projecting head-land the slate inclines to, and in another from, the sea.

Ascending from Portreath, on the road to Tehidy, a quarry, on the right-hand side, shews a lamellar rock, (631.) which has undergone a very partial change, but in other respects it resembles No. 627.

Along the cliffs, the road to Gwithian runs over

an extensive down, and appears to rest on a red decomposing slate, abounding in quartz. Passing over the promontory leading to Godrevy, the rocks (632.) are similar to those of Portreath. At the point, however, they (633, 634, 635, 636.) are more felspathic, like those of Trevaunance Cove, near St. Agnes: some parts of these rocks are white and decomposing; and others exhibit a ribbon-like appearance, arising from a parallel alternation of light and dark coloured laminæ. These rocks are in many parts of the cliff, very tortuous: and the quartz-veins which they contain follow all their flexures. The strata dip eastward, at an angle varying from 25°. to 30°. From this bearing, and from their containing more compact-felspar than the intervening rocks, they, perhaps, are connected with some mass of granite nearer than that at Crowan, which belongs to the central group of this district.

The cliffs at Godrevy Point, afford another example of the diluvial deposit so common on our shores. A ferruginous clay, with angular fragments of rock imbedded therein, form a bed of twenty feet in thickness. The angular pieces are of the same nature as the hill above, which proves that this diluvium has not been transported to any great distance. Beneath this is a bed of rounded pebbles and gravel, many parts of which are consolidated; and some idea of the tenacity of this recent rock may be formed, when it is stated that a detached mass (about eighteen feet long, twelve wide, and three in thickness,) rests across the basset edges of the strata,

in the form of a lintel, or the upper stone of a cromlech; the opening beneath is five feet on one side, and nearly ten on the other. In tracing this diluvium eastward, it will be observed to diminish in thickness as the land rises; so that it is not above a a foot deep on the summit of those cliffs that are formed by a section in the highest part of the hill.

At Gwithian, the slate (637.) is blue, and separates into thick laminæ, which have an uniform smooth surface on the cross fracture; and it is traversed by a massive rock, (638.) like that at Godrevy. Gwithian is surrounded on all sides by extensive hillocks of sand, almost entirely composed of comminuted shells. This sand, when unprotected by vegetation, is liable to be driven about by the wind: and in this manner, as is common elsewhere, it has, from time to time, committed considerable trespasses on the cultivated land. In some parts of these banks there are alternate layers of sand and vegetable remains, consisting of arenaceous plants, the same as now cover the surface; thus marking the periodical increase of sand in these places. These migratory portions of the sand are specifically lighter, and abound more in entire shells than the sand in the valleys next the estuary: the latter is composed of minute marine shells, such as are now common to our shores; the former, almost entirely of land-shells, which in myriads feed on the scanty vegetation of these downs. The remains of these minute animals, accumulating through successive ages, must make a great addition to the sand-banks.

From Gwithian to Camborne, Carnkie, Stithians, and Penryn.

From Gwithian to Trewitham, the road lies over hilly downs, composed chiefly of that quartziferous slate which becomes red on decomposition; and which prevails, with little variation, on a line drawn from this place through Prince's Common, Newlyn, Bogee, and St. Breock's Downs, to the neighbourhood of Wadebridge. As Camborne is approached, the same bluish lamellar slate occurs that is common near Redruth. Between Camborne and Tucking Mill, a large *elvan-course* is quarried; it is (639.) a felspar-porphyry, of the same description as that at Creag Braws; it runs nearly east and west, *underlying* to the north, according to the quarrymen.

At Tucking Mill, a bed of hard compact rock (640.) occurs on the road-side: it is called by the miners *irestone*, and is said to extend a considerable distance. It may be the same as that north of Redruth, but they are not exactly alike; this is more splintery in the fracture, and is spangled by minute shining specks; whereas that of Redruth is granular, with indistinct silky laminæ, resembling hornblende: they, however, both agree in this, that they have a basis of compact-felspar.

Turning southward, you pass through a narrow vale, the steep rounded hills on either hand being covered with loose rubbish from the mines of Dolcoath and Cook's Kitchen. These extensive and productive mines are situated near the boundaries

of the granite; and the phenomena which occur here, particularly in the former, of alternating beds of granite and *killas*, has often been alluded to by geologists, and more especially by Professor Sedgwick, who is of opinion that those of granite are *veins* or wedge-shaped portions communicating with the main mass of this rock. But I am inclined to think that they are entirely independant of the main mass; at least as much so as the schistose rock in which they occur. This subject will be discussed hereafter: but in the mean time it may be observed, that the rocks here are similar to those at Cardrew, Poldice, and Wheal Vor; and, in short, to many other places in the immediate vicinity of the granite: and I believe that the same phenomenon of alternation is more or less common to all.

At Dolcoath the *killas* (641, 642.) is a hard purple coloured rock, which breaks into thick laminæ; in consequence of the minute scales of mica which enter largely into its composition. Sometimes the mica is almost entirely wanting, the rock (643.) is then a kind of compact-felspar; and is (644.) occasionally much intermixed with quartz, more particularly near the *lodes*. The *elvans*, or granitical rocks (645, 646, 647.) are quartzose: the first of these specimens is fine-grained, affording an easy passage into the above compact-felspars; the last is large-grained, contains flesh-coloured crystals of felspar, and approaches nearer to granite.

At Cook's Kitchen the rocks are so similiar to the last that a particular description is unnecessary:—

Nos. 648, 649, 650, 651, are micaceous and compact-felspar rocks; Nos. 652, 653, 654, 655, granitic *elvans*. Some of these specimens shew the rocks in various stages of disintegration.

Ascending the hill from Cook's Kitchen, the granite is soon entered on; it is (656.) of the same kind as that of Carn-Marth: and at Canarthen, it is traversed by quartz-veins, (657, 658.) in which shorl is very abundant.

The granite of Carnkie (659.) is also traversed by thick layers or veins of compact shorl-rock, (660, 661.) which presents an interesting variety, (662.) having large irregular crystals of white felspar interspersed; it may be called porphyritic shorl-rock. On the descent from Carnkie, a bed of porphyry (663.) occurs: its basis is a very hard greyish compact-felspar, containing crystals of flesh-coloured felspar, of quartz, and occasionally of tourmaline, with a few scales of mica.

The granite (664.) of Houghton Downs, between Carnkie and Stithians is of the common kind, but is traversed by a very large bed of fine-grained granite, (665, 666.) which is white and soft, from a partial disintegration of the felspar: it is quarried and works well, like a freestone. This bed runs nearly east and west, and dips towards the south, at an angle of 65°. Between this place and Stithians, several large quartzose *courses* project above the surface; this stone (667.) is of a light verditer blue, and is veined and marbled with transparent crystalline quartz: the nature of the colouring matter is not apparent.

At Stithians, the granite (668.) is beautifully crystalline; its felspar is pure white, its quartz grey, and the mica of a deep garnet colour. A little farther south, at Zeath quarry, nearly opposite Kennal Vale, the granite (669.) is of the same nature, but the felspar is more crystalline, having the lustre of the glassy variety of this mineral. Here, I saw an immense block of this stone, which was without any seam or flaw; and measured forty feet long, by thirteen in width, and twelve feet in height; and must, therefore, have weighed several hundred tons. This kind of granite has a beautiful appearance: it is, however, rejected by the London market; probably owing to its containing a larger portion than usual of quartz, which renders it brittle; and, therefore, not fit for cornices, and other fine work: but it would be well adapted for those parts of a building that require a strong and durable material.

About half-way from Stithians to Penryn, another bed of felspar-porphyry occurs: it (670.) contains small flesh-coloured crystals of felspar, and granules of quartz; some of the latter are the size of a pea, and look as if they had been rounded by attrition. This porphyry contains small dark coloured particles like hornblende, but no mica.

A mile farther south, another stratum of porphyry traverses the granite: it distinctly bears east and west, dipping at a great angle towards the north. In composition it (671.) is quite unlike the last; it is a hard fine-grained porphyry, glimmering with dark coloured mica.

Descending from the granite, this rock is seen for the last time, on the side of the hill just above the Paint Factory: it (672.) contains a larger portion of mica than usual, which causes it to break into thick flags. This kind is said to prevail near the junction at Constantine; but it escaped my notice.

From this place to Penryn, about half a mile distant, compact and slaty felspar-rocks appear to form the substratum;—judging from the soil and the disintegrating fragments scattered around. South of the town, on the road to Falmouth, a blue slate (673, 674.) much decayed, is the prevailing rock: it also appears to be a variety of hornblende-slate.

From Falmouth to Swan Pool and Mawnan.

On the summit of the hill immediately behind Green Bank, (Falmouth) a massive hornblende-rock has been extensively excavated, on account of a large bed of quartz which it contains. This rock (675, 676.) is in a state of decay, the hornblende being converted into an ochreous substance. It runs about east and west, and appears to dip southward, at an angle of 35°. At Swan Pool, the cliffs are formed of a thick lamellar hornblende-slate, (677.) in which compact-felspar appears to predominate, and which is also extensively disintegrated: it dips south-east, at the same angle as the last.

On the sea-shore, a little west of Swan Pool, is a large *elvan-course*, which runs about north-east and south-west, for several hundred feet, and dips east of

south, at an angle of 45°. Near low water-mark it abruptly terminates; but immediately adjoining, on the southern side, it is seen continuing its course in the original direction, so that it has apparently been moved about twenty feet; that is equal to its breadth. At this point, both the slate and *elvan* are traversed by a thin layer of a soft clayey substance, called by the miners *flucan;* which has rather a tortuous course, gradually diminishing in size as it recedes from the *elvan*. Mr. Robert Were Fox obligingly accompanied me to this spot, and pointed out this interesting occurrence; it distinctly illustrates what is termed by the miners a *heave*: but, notwithstanding the whole is here so clearly exposed to view, I could not satisfactorily detect the nature of this phenomenon. This *elvan* (678, 679, 680, 681.) consists almost entirely of compact-felspar, with imbedded granules of quartz, and scales of mica. Next the slate it becomes very siliceous, almost passing into hornstone. It is very prone to decay, as is seen in the adjoining cliff, above high water: the upper part is converted into white clay, (682.) which is manufactured, on the spot, into excellent bricks. No. 678, and the white clay, are precisely like Nos. 339, 340, from the *elvan-course* near Bodmin.

This *elvan* occurs in a hornblende-slate, (683.) which splits into thin and jointed laminæ, it is much curved and contorted, and is traversed by numerous irregular quartz-veins.

At Main Porth, a bed of siliceous sand lies at the head of the cove, forming a bank, (in the same man-

ner as at Mount's Bay) behind which there is also a tract of marshy ground. The rocks here (684, 685, 686.) are similar to those at Portreath and Tregoney: that is, they consist of alternating beds of a glossy shining slate, and a granular laminated rock abounding in scales of mica: such rocks indicate that limestone is not very remote, and if the sea did not intervene, probably the same series of rocks would be found, as at Veryan, Varieties of the same kind of slate and compact rock (687, 688.) alternate in the cliffs to Rosemullion Head; where they are much interlaminated with quartz, as in No. 689. In the cliffs near Mawnan church, the Rev. Canon Rogers was so kind as to shew me the rocks which he has described, in a former volume, as greywacké; but to which I certainly should not apply this name. The rock in question (690.) is coarse-grained, crystalline, compact, and hard; and gradually (691.) passes into (692.) a fine-grained homogeneous mass, and thence into a blue glossy slate: the last (693.) has an irridescent tarnish, and is exactly like that of Tregoney. The basis of the coarse-grained is the same as No. 691, but it contains irregular scaly grains of mica, hornblende, or some such mineral; and is, moreover, mottled with very minute white grains, which break down under the pressure of the knife; and which are slowly dissolved with the extrication of gas, when a portion of this stone is put into dilute muriatic acid. From this I conclude, that this massive rock is a species of greenstone, or hornblende-rock, with the addition of carbonate of

lime. Similar compounds have been noticed near the limestones of Padstow and Veryan: and it, therefore, appears that as these compact rocks recede from the granite, carbonate of lime gradually increases in the compound, till at length they become so calcareous, as to pass into dark coloured limestones, which, on account of a portion of greenstone entering into its composition, is argillaceous, exhibiting those properties for which the lime of Aberthaw is celebrated. From this survey, therefore, it appears that from Main Porth southward to Mawnan, the rocks form a similar series, as those from Tregoney to Veryan. And, perhaps, the reef of rocks extending off Mawnan, may confirm this conjecture.

FROM MABE TO CONSTANTINE: AND THENCE TO PORTHALLA COVE.

About a mile from Penryn, on the road to Helston, you enter on the granite: and thence to Mabe the pathway lies over this rock. In this neighbourhood are numerous quarries of granite; immense quantities of which stone are carried to Penryn, and thence shipped for London. The rock here (694.) contains more felspar, and the quartz is smaller grained, and in less proportion than that of Stithians, above mentioned; and on this its superior quality for ornamental architecture seems to depend. Between Mabe and Constantine, the quarries are also very numerous; and are here called *bals*, a term commonly applied to mines in the western parishes.

No. 695, is from a quarry near Trewardrevah, it consists almost entirely of white felspar, which is prettily spangled with large scales of dark coloured mica. The outline of the granite may be distinctly traced by the form of the country from Mabe to Constantine; it is somewhat curved, and declines rapidly southward, falling into the valley about a third of a mile distant from these places.

From Constantine to Helford, the rocks, that are exposed, are varieties of compact and slaty hornblende-rocks: No. 696, is from Merthen Downs. On the banks of Helford-river the slate (697.) is blue, and splits into thin irregular laminæ which are spangled with mica: and, a little south of the passage, on the hill, it contains a bed of (698.) massive rock.

At Anthony, the rocks are of the same nature as the last; but the slate (699.) is more fissile, and smoother on the surface: it dips southward, at about 30°. It (700.) continues to Prussias Cove: and also occurs at Pedgadnick, another little creek farther to the east; but it is rather more tarnished and changed. These rocks, if not precisely the same, are nearly allied to those on the northern banks of the harbour, viz. at Durgan and Mawnan: and it is curious to observe that all the large creeks, running deep into the land from the English Channel, are almost entirely bounded, on either side, by these kinds of rocks. This does not appear to be altogether owing to their being more susceptible of decomposition, but also to the curved form of their strata, the concavities of which extend lower than the present

sea-level: for the sections of rocks exhibited on the banks of these creeks, seldom rise much above high water-mark.

Proceeding towards the sea, there is on the land side of the Nare Head, a shallow cove, of about half a mile in length, which affords a fine example of fragmentary rocks, to which the term greywacké is more applicable than to any others in Cornwall.

These rocks are of considerable extent, and are seen to greatest advantage near the landing place, which leads to Rostowda: here they lie in scattered masses on the shore, having fallen from the cliff. When I first saw them from the boat, they looked like blocks of granite, and my surprise at seeing such in this situation was not at all diminished when I discovered, on a nearer view, their real nature. Before I could explore the whole of these rocks, or satisfy myself as to their position, and mode of connection with the adjacent strata, the flowing tide and approaching night put an end to the survey. Two days after I returned to this spot and carefully examined it: but, notwithstanding, I could detect no positive evidence on this matter. The cliffs at the western end are composed of a deposit of diluvium at least fifty feet in depth; at the base (just above high water-mark) is a ridge of slate similar to No. 700, which extends into the sea, and abounds in quartz-veins. For a considerable distance eastward, diluvium in the cliffs, and a bank of pebbles at its base, and a sandy shore, are all that meet the eye. A few hundred feet before reaching the landing-place,

(to which point the cliffs, from the right and left, gradually lower, affording an outlet for a little brook,) is a section of this fragmentary rock, about twelve feet in height: to the eastward, the cliff becomes gradually higher, though this increase consists in the diluvium which is superimposed on the rock. At the eastern extremity, towards the Nare, the greywacké terminates abruptly against slate, which resembles that on its western extremity.

Between the greywacké and the slate, a thick layer of a massive pyritous rock occurs; and at the point of junction with the slate it is so decomposed and ruinous, that the nature of the connection cannot be ascertained; but with the greywacké the union appears to be complete,—the one passing into the other. All these rocks pass under the diluvium in the cliff: so that it could not be seen whether the greywacké dipped under, or rested on, the slate; though, judging from the direction of its indistinct layers, it certainly has the appearance of being inferior to the slate. I have admitted the difficulty of deciding this case; but, all things considered, I think that the greywacké reposes on the slate, having been deposited in a basin-like hollow. The only other spot in Cornwall, where secondary rocks occur, is Mount Edgcumbe: and it is a curious coincidence that both these groups of rocks occupy a similar position; being situated within a head-land on the right side of an extensive inlet of the sea. It may also be added, that the adjacent rocks are similar in both cases; consisting principally of slate,

with laminæ nearly perpendicular between the seams of the strata, which dip southward, at about 30°.

At that part of the cliff, where the greywacké is laid bare to the greatest depth, the inferior beds of this rock contain more pebbles of slate and quartz, and larger fragments, than the upper beds: there are some exceptions, but this appears to be the general rule. This is an interesting fact, because it corresponds with the condition of the superimposed and unconsolidated diluvium; indicating that they were produced by the same cause, operating, however, at distinct and distant periods. It may also be remarked that all these greywacké rocks are more or less stained by oxide of iron. I observed, however, one stratum of this rock, which is fine-grained, and exhibits on the edges of its thick laminæ, alternating stripes of deep red, and greyish white; resembling that of No. 201, from Redding Point, Mount Edgcumbe:—this fact shews (as the red and white portions are equally hard) that oxide of iron is not the consolidating agent.

Some layers of the greywacké are schistose, resembling the slate of the neighbourhood: but this is not surprising, as the former was evidently derived from the *debris* of the latter.

To shew this greywacké to advantage in its coarsest form, a large bowlder ought to be obtained; the following specimens will illustrate the other varieties:—Nos. 701, 702, 703, 704, consist of fragments and small pebbles; Nos. 705, 706, are two rounded pieces from the sea-shore, the surface of

which exhibit these fragments more distinctly; Nos. 707, 708, are fine-grained varieties, and Nos. 709, 710, the same, disintegrating; No. 711, is a fragmentary, and No. 712, a fine-grained and slaty rock, from near low water-mark, about a hundred yards from the cliff; No. 713, 714, are striped and fine-grained, passing into No. 715, a coarse compound, which graduates into No. 716, containing a very considerable portion of iron-pyrites; No. 718, is the same rock as the last, only in a decomposing state; No. 719, is the coarse slate of the district which occurs in contact with the last, and it is sometimes (720.) much stained with red oxide of iron.

Proceeding along the coast from the greywacké, slate (721, 722.) succeeds: which is similar to No. 700, and evidently dips west of south, at an angle of 30°. The slate (723, 724.) at the Nare Head, is of the same nature, and has the same bearings: the land at the last place runs out into an almost horizontal point, not much elevated above high water-mark: but it suddenly rises landward, into a steep rounded hill, consisting of a hard rock, (725.) in which quartz abounds.

Going along a path above the cliff from the Nare Head to Porthalla Cove, there is, about midway, a natural section which exhibits the slate (726.) containing beds of (727.) a dark compact rock: these are of more uniform texture than the last, approaching nearer to the rocks around Helford. Descending into Porthalla, the cliffs on the eastern side of the cove are composed of different rocks: the most

easterly one (728.) is a blue slate, with irregularly curved laminæ, resembling those strata which occur so often, in the eastern district, in conjunction with the calcareous slates; and this slate, to the westward (729, 730, 731.) also abounds in veins of calc-spar. The slate next the village, is decomposed to a considerable depth, and is of a dirty yellowish white: the perfect rock includes, between its laminæ, wedge-shaped pieces of (732.) a compact substance, evidently an intimate compound of the slate and calcareous spar, resembling the black limestone of Veryan and Padstow; and of which (733.) a massive bed may be seen at low water. These rocks dip southward, at an angle of 30°. to 35°. About a quarter of a mile up the deep valley which runs from the cove towards St. Keverne, the decomposing compact rocks (734, 735.) may be seen running east of north, and west of south, but the dip is not apparent.

On the road to St. Keverne the rock is exposed near Parkantednoc, it (736.) is a fine-grained lamellar slate of a greenish colour, and breaks into thick rhomboidal pieces, like the hornblende-slates near the granite. At Trenance the rock (737.) also much resembles a hornblende-slate, and includes hard massive layers of No. 738:—the nature of these is obscure, owing to their being partially disintegrated. At the road-side a little above Porthoustock, the rock (739, 740.) is the same as No. 736, all of these appear to dip east of north, at an angle of 35°:—that is to a point of the compass nearly the reverse of the rocks north of Porthalla.

From Porthalla to Coverack, along the Sea-coast.

I left Falmouth in company with Mr. Henwood, but after the first day we parted; his object being to examine the coast minutely, and mine to gain a general knowledge of the county by frequently traversing it from the central masses of granite to the sea-shore. Having, therefore; omitted to visit the serpentine between Porthalla and Dranna Point, Mr. Henwood has obligingly supplied this deficiency by giving me the following specimens with the annexed memoranda.

"On leaving Porthalla the first beds that occur between the slaty rock and the serpentine, are in a ruinous state, as described by Professor Sedgwick, and of which No. 741 is a specimen:"—it is a soft red slate, glossy and irregularly laminated, its nature is not very obvious, but it appears to be derived from No. 742, a bluish white talcose-slate, with reddish stains, which is not in such an advanced stage of disintegration, and which I obtained from a pit about one third of a mile from Porthalla, on the road to Porthoustock. "No. 743, is the slate adjoining the serpentine. These schistose beds contain No. 744," which is quartz containing very minute grains of talc, imparting an obscurely laminated structure. "The first bed of serpentine (745.) in this direction," is of a dark olive green, very profusely spotted and clouded with reddish brown. "The second bed of serpentine (746, 747.) is eastward of the first." It

is of an uniform dark olive green; and, with the exception of precious serpentine, it is the finest grained, and most compact kind, that I have met with. "On the side of this serpentine, next to the last, a bed (748.) occurs," which consists of laminæ of a reddish brown alternating with others of a greyish colour, lightly tinged with green. It appears to be a compound intermediate between the slate and serpentine. "No. 749, is interposed between the second and third bed of serpentine," and, with the exception of the stripes, it is of a similar nature as No. 748. "Nos. 750, 751, are specimens of the third bed of serpentine, which is succeeded by No. 752," a compact hornblende-rock, approaching somewhat to the slaty structure: it is situated eastward of all these beds of serpentine.

At Porthoustock, a dark blue hornblende-slate (753.) forms the eastern side of the cove: the layers of which decidedly dip west of north, at 35°. I have called this a hornblende-slate, but it is not exactly like those of the other parts of Cornwall: it breaks indeed into thick angular rhomboidal pieces, the joints of which are ochreous, from the decay of iron-pyrites, as may be seen in this specimen: it is, however, more compact and harder, and its surface is glimmering from minute shining specks. On the western side of the cove, this slate contains beds of (754.) a harder and apparently more siliceous rock.

It is an interesting enquiry to ascertain the extent and bearings of these rocks, in the neighbourhood of Porthalla and Porthoustock. This, however, is

no easy task; for here, as in all parts of Cornwall, the rocks do not continue far in the same direction, but are curved and contorted; and continually varying in their composition. The hornblende-rocks dip sometimes east, and at others west, of north; their bearings may, therefore, be nearly east and west, dipping northward, and rather west of north, at an angle of about 30°. This corresponds with the deep valleys here, and with that which forms the estuary of the river Hel. Whether the serpentine of Dranna alternates with the hornblende-rocks in long continuous beds, extending as far as the northern end of Goonhilly Downs, is not apparent: one circumstance only occurred to me which seemed to favor this conjecture,—viz. that in this direction, north of St. Keverne, there is a narrow strip of ground not so fertile as the adjacent land: and at one place the hedges near it were composed of stones resembling that obscure rock of Dranna, No. 748, that appears to be intermediate between hornblende-rock and serpentine. I am, however, rather inclined to regard these beds of serpentine at Dranna, as distinct and unconformable masses, imbedded in the schistose rocks, after the manner of the greenstones in the hornblende-slate of Mount's Bay.

Proceeding over the hill to Manacle Point, the dark decomposing hornblende-rocks are succeeded by a massive crystalline compound of felspar and diallage. This rock varies in appearance, according to the proportions and size of its constituent minerals, which are aggregated together after the manner of

granite: indeed this rock greatly resembles granite on the large scale, projecting at the brow of the hills in immense blocks, piled one above the other, and which are also strewed over the sloping ground beneath. Its felspar is generally pure white; but in some places, in consequence of an intermixture of diallage, it assumes a violet, or sometimes a dull green, colour. This rock extends along the coast, all the way to Coverack; and inland as far as St. Keverne, and to the foot of the serpentine at Goonhilly Downs. It appears to *underlie* towards the north; as the longer sides of the quadrangular masses, that compose the Tors, incline in this direction: but as in the case of all massive rocks, whether of granite or of porphyry, it is not easy to form an opinion on this point. Nos. 755, 756, are specimens of this diallage rock, from the hill a little south-west of St. Keverne: and No. 757, from an excavation at the same place, shewing the last kind in a state of disintegration; and affording another example of the greater rapidity with which rocks decay, when covered with the soil, than when they are exposed to the air; for that from the Tor, although covered, as granite, with lichens, is quite fresh and perfect immediately beneath the surface. A bed of this rock, at the Manacle Point, consists almost entirely of felspar, (758.) with imbedded prismatic crystals of hypersthene:—and in the cliff, immediately opposite the Manacles, some layers may be seen, composed almost entirely of (759.) diallage.

Along the coast a variety of this rock occurs,

which (760.) is fine-grained, and exceedingly tough: it is imbedded in irregular masses and veins in the more distinctly crystallized kinds; and it sometimes projects in entire blocks. The transition between these is so distinct, that its nature is evident: I did not see it passing into the lamellar slate, No. 753; but No. 760, is a near approach thereto, resembling No. 754, which is imbedded in the slate at Porthoustock. The following specimens of diallage-rock, No. 761, 762, 763, were taken about equal distances from each other, between Wrea Point and Coverack.

As Coverack Cove is approached from the east, the land falls rapidly to the bottom of the narrow valley, and abruptly rises on the opposite side, where serpentine makes its appearance, forming the boundary of that extensive mass which, with little interruption, continues from hence to the Lizard.

The western side of this cove, towards the quay, is bounded by a perpendicular cliff; the lower part of which consists of serpentine rocks, but the upper, and greater portion, of diluvium which is of a bright ochréous colour, and which, next the rock, is (764.) partially consolidated, containing small pebbles of quartz, compact-felspar, and serpentine. The first serpentine (765.) that presents itself, in this direction, is dark brown, very fine-grained, and compact; having a splintery and somewhat conchoidal fracture; and is spangled with large scales of green diallage. This passes into (766.) another variety of a darker colour, with brown diallage: it contains a layer of a very dark crystalline rock, (767.) apparently compo-

sed of felspar and diallage; the scales of the latter constituting the greater portion of the mass.

The serpentine (768.) succeeding the last is very similar to No. 765, but rather inclined to a reddish brown tint: some of its layers are (769.) crystalline, like No. 767, only interspersed with spots of a deep reddish brown, which are rather pulverulent, and are produced, perhaps, by the disintegration of diallage: veins of which mineral are here very abundant, and are often large and irregular; they afforded the following specimens;—laminæ of (770.) diallage metalloïde, bounded on one side by a layer of steatite; No. 771, consists of the same mineral, imbedded in a variety of compact-felspar; No. 772, is the same felspar passing into indurated and opalescent steatite; No. 773, another variety of compact-felspar, or jade, of a violet colour; and No. 774, the same, more intermixed with diallage. As regards these minerals it must, however, be observed that they do not exactly answer to the descriptions of jade and steatite: I have used these terms for want of better, and because others have done so before me. The compact minerals, like steatite, are nearly as hard as calcareous spar; and those, like jade, so far from scratching quartz, readily yield to the knife: indeed they may be all considered as varieties of compact-felspar, inferior in hardness to those which occur amongst the rocks near the granite; as is likewise the case with the crystalline felspar of the diallage-rocks, which have been just described. Analysis would probably shew, that

magnesia enters into the composition of all these minerals: and that the variable proportions of this earth give rise to the different kinds of felspar in serpentine; as in like manner, silica produces that endless *suite* between compact-felspar, hornstone, and even jasper, which characterise the porphyritic beds in the vicinity of granite.

At the back of the pier, there is a similar repetition of these magnesian rocks; indeed the difference is too trifling to need description, as may be seen in Nos. 775, 776, 777, 778, 779, 780. It may, however, be observed that one of these beds (781.) exactly resembles the diallage-rocks that prevail from Porthoustock to this place. Farther enquiries may, therefore, ascertain that serpentine also occurs along this tract, imbedded in, and alternating with, this massive diallage-rock.

The ridge of rocks running southward from Coverack Point, consists of dark brown, fine granular serpentine, (782.) the texture of which is very uniform, being only diversified by very minute shining specks, when viewed in a strong reflected light. It is traversed by veins of that kind of indurated opalescent steatite above alluded to, which (783.) is of a greenish yellow, veined agate-like, with white layers of the same mineral.

This dark homogenous kind of serpentine continues to Chynhals Point, where it is much intersected by veins of steatite, by which this rock is sometimes divided into small quadrangular blocks, as is disclosed on disintegration.

FROM WENDRON TO HELSTON, GOONHILLY DOWNS, AND KENNICK COVE.

The country around Wendron consists of the same kind of (784.) granite, as that of the high hills near Redruth: and it is traversed by beds of (785.) fine-grained granite. The valleys near Wendron have been much explored for tin-ore: and the diluvium, under which it occurs, has evidently been derived from a granitic district, and is interspersed with large pebbles, and bowlders of quartz, and of compact shorl-rock (786.) which so frequently traverses the cornish granite, in the form of large contemporaneous veins.

At Trumpet tin-mine, a little south of Wendron, the granite (787, 788.) is very crystalline; its white felspar is in excess, and is generally in the form of (789.) large porphyritic crystals. One kind of this granite, (790.) though quite hard and unchanged when brought to the surface, becomes in two or three years quite disintegrated: and indeed adjoining the *lode*, it is frequently in this condition to a considerable depth. The *lode* (791, 792.) is what the miners call a *capel;* and the granite (793.) in contact therewith, partakes of its nature, consisting of large flesh-coloured felspar, imbedded in a basis composed almost entirely of quartz, blended with a small portion of mica, and of a pulverulent substance, intermediate between this mineral and chlorite. Some part of the *lode* (794.) is of a dark red, apparently from the oxidation of this micaceous substance; and

the adjacent granite (795.) is occasionally discoloured from the same cause. No. 796, is a part of the *lode* in which the mineral is more like chlorite.

Half a mile south of Trumpet mine, and about a mile north of Helston turnpike, is the boundary of the granite; which rock appears to run in an easterly direction to Constantine, crossing the Penryn-road, about a mile and half from Helston.

Near this boundary, the only rocks that present themselves are massive greenstones, such as prevail near granite: No. 797, is from a projecting ridge by the side of the Wendron-road, a quarter of a mile north of the turnpike; and No. 798, is from Trelill.

The rubbish around the abandoned mine, near Helston, shews that the country here is composed of the same kind of thick laminated slate, that occurs at Tolgus and elsewhere, at about the same distance from the granite: it is blue when perfect, but rapidly becomes whitish (799.) from disintegration; next the *lode* the slate (800.) is of a dark blue, and glossy.

Leaving Helston by the Lizard-road, it is soon evident that the rocks are changed; for the country becomes bleak and barren; the soil full of quartz, and fragments of reddish slate, as at Prince's Common: this continues past the meeting of the Gweek-road; where, near Grange, the slate (801.) is whitish, decomposing, and stained with red lines at its numerous joints: this rock extends right and left to a considerable distance; to the eastern banks of the Looe Pool on one hand, and to Merthen Downs on the other. Approaching Rosevear, another kind of

rock is entered on: it is a fine fissile blue slate, (802.) including (803, 804.) thick laminated micaceous beds; and extends from thence in the direction of Helford-river, as far as Mawnan and the Nare. It is worthy of remark that this rock, succeeding the red decomposing slate, gives rise to the same roundish and precipitous hills here, as at Portreath, Towan, and elsewhere.

From Rosevear, by a steep ascent, the serpentine is entered on: and is first exposed to view at a quarry a little north of Trelowarren-gate, on the road to Coverack. This serpentine (805, 806, 807.) is of a dark olive green colour, and of the same nature as that at Dranna; and it is coated at its joints, and traversed by veins of that indurated steatite noticed at Coverack. This rock is here well exposed to view, divided by parallel seams into layers, which appear, in one part, to dip south, at an angle of 35°.; in another, quite the reverse: for as these layers are again subdivided into quadrangular blocks, it is not easy to determine which side is in the direction of the strata; if, indeed, any such exist.

For about four miles the road lies over Goonhilly Downs; and the country around is level to a greater extent than I have seen in any other part of Cornwall. The descent from this elevated plain is near Trelanvean and Roskelly; the rocks are not exposed to view, but the numerous farm-houses appear to indicate that the serpentine is no longer present.

A little farther southward, is a flat and unenclosed common, which is thickly strewed over with large

blocks of diallage-rock, (808.) like that between Coverack and the Manacles.

A little east of Gwinter, serpentine (809.) is exposed; it is very brittle, breaking into angular and splintery fragments, the surface of which is smooth, shining, and of a very dark colour: it appears to dip northward. In contact with it is an exceeding hard and massive rock, (810.) of a dark brown colour: it is not unlike the hornblende-rock at Porthoustock, and probably bears the same relation to it, as the compact hornblende-rocks do to the slates in which they are imbedded. Adjoining the farmhouse of Gwinter, the rocks project from beneath the soil in the form of tors; and bowlders of the same lie scattered around. The most abundant kind (811.) is a variety of diallage-rock, consisting of a fine intermixture of felspar and resplendent hornblende; but another kind consists almost entirely of felspar, (812.) being only speckled with a light blue violet coloured mineral; and sometimes it (813.) is entirely of a deep violet, and resplendent with numerous crystalline laminæ of diallage.

These felspathic rocks extend to Black Head, where they form the more prominent parts of the cliff, bounded on either side by serpentine. Here is a large and well known bed of that kind of indurated steatite, so often alluded to; it (814.) is beautifully marked with brown arborescent figures on a yellowish ground: it can only be obtained from detached portions of the cliff; and for this specimen I am indebted to the Rev. Henry Coulson.

From Gwinter to Kennick Cove, the hill declines steeply towards the west, and terminates in a deep narrow valley, which affords an outlet to a small stream of water. This cove is of considerable extent; it is covered with fine sand, and is bounded on either side by very precipitous cliffs. The eastern side of the cove is formed of red serpentine, (815.) which derives its colour from crystalline laminæ of diallage, like No. 770, at Coverack: from the appearance of some recently broken blocks, I am inclined to think that the deep red does not belong to this mineral in a perfect state, but is occasioned by a partial oxidation. This red serpentine is traversed by a thick bed of a very hard rock, (816.) apparently composed of crystalline grains and scales of white and cinnamon coloured quartz and felspar: the surface of this rock is corroded into small irregular pits, from the decay and abstraction of the latter mineral. This bed runs north-west, and south-east, and dips north of east, at a considerable angle. It is the equivalent of the felspar-porphyries in the hornblende-rocks, near the granite. In the red serpentine are also beds of an olive green (817.) serpentine, which is very fine-grained, and of an uniform texture: it is traversed by veins (818.) of talc and steatite, containing large crystalline laminæ of red diallage, in which is imbedded a dark mineral, like chromate of iron.

The rocks at the base of the low central hill at the head of the cove, (819, 820.) are also of red and olive green serpentine; they can hardly be said to

alternate, although on some spots they have this appearance: but are promiscuously associated. The green variety contains scales of greenish yellow diallage, which in the sun shines like gold; and is thickly studded with silvery scales of talc which in the rock look greenish; but when detached, prove to be white and transparent.

A little farther west, similar kinds (821, 822.) also occur; and are traversed by thick veins (823, 824.) of talc, fibrous and indurated next the rock, but crystallized in the middle of the veins.

The cliffs, near the road leading to Ruan Minor, are formed of rocks of a different character. The predominant rock (825.) is a kind of greenstone, of a dark colour, with shining crystalline grains which are very minute. Viewed through the magnifying lens it appears to consist of white semi-transparent felspar, and black hornblende: or perhaps of some magnesian varieties of these minerals. This greenstone contains beds of a hard compact rock; and is traversed by ramified and irregular veins of the same: it is similar to No. 816, on the eastern side of the cove, with the addition, however, of the last mentioned kind of hornblende. Some layers (826.) of this rock consist of minute scales of hornblende, distinctly arranged in parallel rows, in a basis of white crystalline felspar and quartz: others (827.) are formed of a more intimate and granular mixture of these; and sometimes they are coarse-grained; (828.) and the felspar is separated into distinct concretions. This appears to be the rock, which has

been called granite by Sir H. Davy,* and lately by Oeynhausen and Decken:† it certainly is analogous to the granitic compounds, that occur in the felspar porphyries, but cannot be considered in the light of granite veins. This rock, as just stated, throws out irregular veins into the adjoining greenstone; and the same is seen intersecting the serpentine in the cliff above: it has a curious appearance; for it first runs along a reef of rocks, and then rises perpendicularly; but if the abraded rocks could be replaced, the singularity of the case would vanish.

The red serpentine of the adjoining cliff contains a large bed of a beautiful rock, (829.) composed of a soft talcose kind of diallage, and an indurated rose-coloured steatite.

FROM KENNICK COVE TO THE LIZARD.

About half-way up the hill, on the road to Cagar, a compact rock (830.) projects on the road-side; it is similar to No. 827, and of which it is, without doubt, a continuation.

At Cagar there is a large quarry of serpentine, (831.) which is very dark, fine-grained and compact; in certain positions shining laminæ may be seen, but otherwise it is homogeneous; for though a fractured surface exhibits minute spots of a pale green colour, this arises from thin half-abraded pieces admitting the passage of light, in consequence of this compact serpentine being translucent at the edges.

* Vol. I. p. 46. † Phil. Mag. and Annals of Philos. for 1830.

At Poltesca, just above Callean Cove, the serpentine (832.) is similar to the last; being of a very dark olive green, approaching to black; but it contains scales of a light coloured diallage.

At Ruan Minor the serpentine is of a reddish brown, like that of No. 815, at Kennick Cove.

Turning into the path through the fields, where Cadgwith Cove first comes in sight, the serpentine (833.) projects in a considerable mass. It is of a reddish brown colour, and breaks into thick laminæ, in consequence of its containing numerous minute scales of resplendent hornblende, which are arranged parallel to these laminæ. This schistose serpentine dips east of north, at an angle of 40°.

About a hundred yards farther on, the path turns again into the road; and there is a section of the hill, which shews the rock (834, 835.) to be the same kind of resplendent hornblende-slate, as noticed at Porthoustock: the upper part of this slate (836.) is in a state of disintegration. Some of the layers of this rock are striped by numerous quartz-veins running parallel to the laminæ. At Cadgwith the same slate (837.) as the last, occurs on both sides of the cove; but it is harder, and affords more perfect specimens than the former: it may be most distinctly seen dipping east of north, at an angle of 35°.

About half-way up the hill, on the road leading to the Lizard, serpentine again makes its appearance; it (838.) is of the red variety, and appears to form the promontory on the western side of the cove: the inclination of the blocks, projecting above the

soil, corresponds with that of the adjacent hornblende-rocks. The hill ascending to Landewednack is also composed of (839.) a red fine-grained and homogeneous serpentine. Around the church the land is very good, derived from the decomposition of hornblende-rocks, which (840, 841.) again occur at Perranbouse Cove, immediately at the foot of the hill. The bearings are the same as at Cadgwith.

At Housall Cove the hornblende-slate (842, 843.) again occurs; and in many parts of the cliffs it is traversed by short and irregular veins of quartz and of calc-spar, or of both these minerals associated, and even intimately blended together, as in the slate adjoining the limestone at Polcouta, near Veryan; these veins are also curiously corroded into a honeycomb mass, owing to the solution and abstraction of the calc-spar. The rock, (844, 845.) immediately in contact with these veins, is very much altered; and those parts of it, (846.) which more particularly abound therein, have their entire mass changed: and sometimes (847.) particles of calc-spar so predominate, that this mineral may be almost regarded as a constituent part of the rock. This hornblende-slate, (848.) in some parts of the cliffs, is striped with parallel layers of quartz, as at Cadgwith.

On going from Landewednack church to the Lizard, a small barren tract is passed over at Tregaminion, immediately adjoining the school: and the nature of this change is explained by the numerous projecting ridges of serpentine (849.) which is of the same kind as No. 839. On the other side of

this tract, next Lizard town, the serpentine (850.) is black, and sparkling with hornblende. And a little farther on, south of this place, a ridge of greenstone crosses the road; the ingredients of which (851.) are very distinct, more particularly the hornblende, which is crystalline and in excess.

Adjoining the lighthouses, the rock is more schistose, and is exposed to view, on the side of the path leading to the sea-shore: the upper part of it (852.) is of an ochreous yellow, in consequence of a partial disintegration, but at the bottom of the cliff, it (853, 854.) is more perfect, and of a dark grey colour; it is soft, and separates into irregular laminæ, the surface of which is very glossy. A great discrepancy of opinion appears to exist concerning the nature of this schistose rock; many geologists have called it mica-slate, whilst Dr. Thomson and others have pronounced it to be clay-slate, with a micaceous gloss: to me it appears to be a variety of talcose slate, having the same relations to the type of this rock, (that is to the compound of talc and quartz) as the slate of St. Breward has to true mica-slate;—the base in both cases being a granular compound of felspar and quartz, as indicated by its great tendency to disintregration, whilst the mica and talc continue unchanged. That talc, and not mica, enters into the composition of this slate, appears to be proved by its occurring in distinct scales in the irregular quartzose nodules, (855, 856.) which abound between the laminæ of this rock.

This talcose slate is full of short irregular veins

of quartz; and of this mineral united with calc-spar, as at Housall Cove: and towards the south, it is in contact with, and gradually passes into, a bed of an iron grey rock (857.) which is very hard, and contains minute particles of calc-spar. Farther from the slate this massive rock is much stained with red, (858.) proceeding from the oxidation of iron-pyrites, which may be seen at the joints of No. 857.

The reef of rocks which at low water may be approached at a considerable distance from the shore, is composed of (859.) a hornblende-slate, traversed by beds of compact-felspar (860.) which is granular and quartzose, not unlike that at Kennick Cove.

FROM THE LIZARD TO MULLION.

About a quarter of a mile north-west of the Lizard town, on the side of the hill leading to the downs, red serpentine (861.) again makes its appearance, and runs to the north of Poltreath Cove. The same continues to Kinance Cove, where it (862.) is of a more uniform and brilliant red colour. This cove is one of the most beautiful on the Lizard-coast, and is much frequented and admired for its rocks, and the picturesque portions of the cliff which have been detached from the main land: one of the largest of these has received the name of the Asparagus Isle, on account of this vegetable being indigenous thereto. The serpentine here presents great varieties, some of which have been beautifully polished by the waves; the red and dark olive green,

both plain and spangled with different coloured diallage, are common. I also observed thick irregular veins of (863.) a light greenish grey; and a dark olive precious serpentine, (864.) which in the mass is opaque, but in thin pieces is translucent and of a rich green. Here also, in short and irregular beds, and angular veins, is the same kind of quartzose rock, intermixed with felspar, (865.) which has been noticed at the Lizard Point, and at Kennick Cove.

From Kinance to Gue Graze, the path lies over a level barren downs, only diversified by crags of serpentine projecting above the furze and heath, in the vicinity of the sea-cliffs. At Gue Graze, the soap-rock (866.) occurs, as a bed or layer in the serpentine, but which has been too often described to need more particular mention. Near this soap-rock is an extensive bed of precious serpentine (867.) which is of a fine dark brown, when viewed through its translucent edges; No. 868, is the same, somewhat intermixed with the red serpentine; and No. 869, is from a vein of indurated steatite, nearly allied to the soap-stone. Sir H. Davy* states that this stone is not a decomposed mineral; but it seems to be analogous to *china-clay*.

On the ridge that runs out to form Vellan Point, the serpentine (870.) is dark coloured and glimmering, from numerous minute specks; and is harder than that just past over. This kind frequently occurs near the hornblende-rocks; and, therefore, indicates that these are not far off: and accordingly,

* Vol. I. p. 44.

a little farther on, at Lower Pradanack Cove, these rocks (871.) form the cliffs; and are exactly of the same nature as those at Cadgwith.

Immediately north of Higher Pradanack, the downs lie on a dark compact serpentine (872.) which contains large scales of diallage; but descending from the downs to Mullion Cove, the serpentine (873.) protruding by the road-side is harder, and bespangled with minute scales; it separates into laminæ of about an inch in thickness, the joints of which are glossy, with a greenish yellow steatite. This lamellar structure of the serpentine was also noticed near its junction with the hornblende-rocks at Cadgwith; and it seems to constitute the layers that are interposed between these rocks, and through the medium of which the transition into each other is effected. This lamellar serpentine extends to the sea, forming the left point, and part of the side of Mullion Cove. The upper part of this cove, however, consists of hornblende-slate, (874.) which contains beds of a more crystalline and massive variety (875.) not unlike No. 851, at the Lizard. The hill on the northern side of this cove, is composed of a dark serpentine (876.) which runs as far as the southern end of Bolerium Cove. I did not go on Mullion Island; but, from the nearest headland, it appears to be composed partly of serpentine, and partly of hornblende-rocks. From the Lizard to this place, the strata exhibit but few instances of a decided dip; and in these it varied from east to north-east, at an angle of about 35°. to 40°.

From Mullion to Looe Pool.

On the southern side of Bolerium Cove, are the same kinds of hornblende-rock, (877, 878, 879.) as at Mullion: and advancing towards the head of the cove, these rocks become more compact, harder, and of a more uniform and finer texture; they (880, 881, 882.) are generally of a dark blue, but sometimes of a bluish white, (883.) and in hardness and appearance approach near to hornstone, or rather to that kind of quartzose compact-felspar that is so abundant in the neighbourhood of St. Cleer. The joints of the dark blue rock are slightly coated with calc-spar; and the farther you recede from the resplendent hornblende-rock, No. 881, calcareous spar becomes more and more abundant: as observed at Housall Cove, the rock (884.) is altered in appearance adjoining the large veins of calc-spar; some of these veins (885.) consist entirely of the fibrous variety of this mineral. Near the head of this cove the rock (886, 887.) is in a very ruinous state, of a rust-colour, and thoroughly decomposed: the calc-spar may assist in this decay, but it is in a great measure owing to iron-pyrites, which is copiously disseminated throughout the rock.

The rocks that occur northward of the last, form the base of the low cliff adjoining the road; and are of a different nature from any between this and the Lizard. The slate (888, 889.) breaks into regular thin laminæ, having a smooth surface; and contains alternating layers (890.) which are coarse, arenace-

ous, and abounding in minute specks like mica: in short, these rocks resemble those at the Nare, near the commencement of the serpentine on the eastern coast. It is a curious circumstance, but one that seldom fails, that when any sudden and great alteration in the nature of the rocks takes place, the layers next the junction are in a state of great decay. Perhaps galvanism may be evolved by the contact of dissimilar strata, and facilitate this decomposition: or it may be, in some measure, owing to an obstruction in the percolation of water, the direction of the laminæ of the rocks, in juxtaposition, being opposed to each other; for it is well known, that where water is accumulated, as in the case of *lodes*, the rock is oftentimes more extensively disintegrated, than in those parts that are remote therefrom.

Rocks similar to the last continue to Poljew Cove: on the left-hand side of which the slate (891, 892.) is more fissile; and, at the joints, have those curved markings, so often noticed in rocks of this kind; the compact beds (893.) are more micaceous than the last, and are of a yellowish colour from a partial disintegration; but on the other side of the cove it (894.) is perfect, and of a dark blue.

At Gunwalloe Cove, the slate is more smooth, glossy, (895.) and fissile, resembling that at Godrevy Point, on the north coast; and like it also the compact beds (896.) by which it is traversed, are more felspathic, and decompose into a soft white clay. No. 897, from the same place, is intermediate, both in position and in nature, between the two last. The

lower part of the diluvial deposit which here rests on the rocks, and forms the cliff, above high water-mark, has been consolidated; and, judging from its ochreous colour, this has been effected through the agency of carbonate of iron: the lowest part of this bed is (898.) a conglomerate of rounded pebbles, and fragments of slate; on this rests (899.) a large-grained sandstone; and above it (900.) a fine one possessing but a very slight degree of cohesion, and this passes upwards into a loose unconsolidated bed of earth. This deposit reposes horizontally on the ends of the strata, which here, as well as at Poljew, dip S. E., at an angle of 30°. From hence to Looe Pool, is an extensive strand of siliceous sand: and, in the hill above the cliff, the same kinds of schistose and compact rocks as the last (901, 902, 903.) alternate with each other. The eastern side of the Looe Pool, about two miles from Helston, is barren; and is formed of slate which becomes red on decomposing, and abounds in quartz-veins, as at Helston Downs, and Prince's Common.

From Hayle to Godolphin and Tregonning Hills, Wheal Vor, Sithney, and Helston.

Around Hayle, a dark blue hornblende-rock (904.) prevails; it is prone to decay, by which it becomes of a yellowish colour, and full of innumerable joints and fissures. It contains beds of a compact rock, which is blue when perfect; but it is changed to a considerable depth, being almost converted into an

indurated white clay, stained at the joints by iron, as in Nos. 905, 906, 907, 908, which resemble the compact rock at Godrevy and Gunwalloe. These rocks dip east of south, at about 30°.

Between Trelisick and Norman's Land, a thick lamellar slate (909.) occurs, and next the quartz-veins it (910.) is of a darker colour, and soils. On the down between Fraddam and Pooley, a decomposing red hornblende-slate (911.) is exposed in several places; but I could not obtain a perfect specimen of the rock. It contains compact hornblende-rocks: in one kind (912.) the shining laminæ of hornblende are distinct; but in another (913.) this mineral is intimately combined with the compact-felspar, forming a well marked greenstone.

At the bottom of the hill at Kerthen, the slate (914.) is cut through by the road: it is a light blue felspar-slate, interlaminated with scales of a micaceous mineral: on decomposing, it (915.) becomes much stained with iron, particularly at the joints.

At Godolphin Bridge, the numerous shafts shew that the rock is a blue slate, (916.) full of dark, almost black, granules; it resembles that at Roach, St. Stephens, Cligga, and elsewhere, adjoining the granite: on decomposing, it (917, 918.) becomes whitish, and the spots of an ochre yellow. Crossing the bridge and immediately ascending Godolphin Hill, the slate is seen to extend about a third of the way up the slope; and is then succeeded by (919.) granite: this rock is coarse-grained, but differs somewhat from the common cornish granite, in having a

basis of granular felspar, which readily decays; and in which, white crystals of felspar, nodules of clear quartz, and black mica, are thickly imbedded. On the eastern part of this hill, next the Great Work mine, the rock (920.) is of the same description. This hill is traversed by numerous quartz-veins of considerable size, which protrude in the form of short and disjointed ridges: many of these abound in shorl, (921.) both distinctly crystallized and intimately combined with the quartz, giving rise to large blocks of granular and compact shorl-rock.

The granite (922, 923.) from the Great Work is similar to the last, but is in a more perfect state: in some parts of this rock the felspar is red. The *lode* (924.) consists of white crystalline quartz, and a beautiful dark green chlorite: the ore is oxide of tin, of a superior quality. At the lowest part of the hollow curve between Godolphin and Tregonning Hills, the rock (925.) near the surface, has a schistose structure, separating into thick laminæ, which, on the cross fracture, are marked by lines parallel thereto: this rock is much decayed, and stained by red oxide of iron; it is probably composed of granular felspar, interlaminated with mica.

Tregonning Hill appears to consist almost entirely of a talcose granite, (926.) very like the china-stone of St. Stephens: indeed some parts of it is extensively decomposed, and has been worked for china-clay. This kind of granite contains large beds (927, 928.) composed almost entirely of granules of white quartz, the interstices being occupied by a yellow granular

talc. There are, however, in this hill some beds of fine-grained granite, (929.) which has been quarried on a great scale, as a building stone, more particularly for window-sells, lintels, pillars, and other ornamental parts, for which purposes it is well adapted, as it splits readily into long blocks and slabs; it is generally called Breage stone, as it occurs near the village of this name. The rock at the upper part of the quarry is much disintegrated.

From Tregonning Hill, through the extensive mine of Wheal Vor, the successive shafts exhibit an interesting series of rocks: but before describing them it may be observed that the hills just passed over form an insulated mass of granite, being separated from the main patch of granite at Wendron and Crowan, by a long trough or channel of slate.

The rocks, next the granite of Tregonning, are precisely of the same description as those at Dolcoath and Cook's Kitchen, already noticed: viz. alternating beds of massive and lamellar rocks. The latter has been often called *killas* by geologists after the miner: but although this distinction may be sufficient for practical purposes, it conveys an incorrect idea of this rock, which like the massive variety is principally composed of compact-felspar. So likewise the massive rock has been called granite, but it is, in fact, a felspar porphyry with imbedded crystals of felspar, quartz, and mica; which minerals are sometimes entirely wanting, and at other times so far predominate as to produce a granular compound, like true granite. On this view of the subject, there is

no difficulty in conceiving that all these varieties should alternate with, and gradually pass into, each other. The heaps of large fragments around the shafts near Carleen, shew these rocks united together, and confirm both their contemporaneous nature, and the report of the miners, that they alternate: No. 930, is felspar-slate, like that of Dolcoath;—No. 931, patches and irregular veins in the last, consisting of quartz, felspar, and mica, separately crystallized in large pieces, the mica is of a dark garnet colour and brittle; No. 932, shews the junction of the purple felspar-slate with white semi-crystalline compact-felspar; No. 933, forms the connecting link between the last and No. 934, which is a granular compound, such as is often found in the middle of felspar porphyry, and which resembles granite; No. 935, exhibits this granite rock traversed by a metalliferous quartz-vein. Still proceeding eastward from the granite of Tregonning Hill, we find, at the next shaft, (936.) a blue slate more fissile than the last, with fibrous markings on the fractured surface sometimes parallel, sometimes stellated;—Nos. 937, 938, are specimens of this rock in different stages of disintegration, and No. 939, a fissile silky blue slate, containing veins of quartz, (940.) which are separated into two parts longitudinally by crystallized talc; Nos. 941, 942, 943, 944, are a succession of schistose rocks of a similar nature to the last, gradually becoming more regularly laminated;—No. 945, is a slate almost black and decomposing into (946.) a red friable mass, in this rock the quartz-veins (947.) are

much intermixed with compact shorl-rock; this slate occupies the middle of the valley between the Tregonning and Wendron hills, and is, therefore, on either hand the most remote from the granite; it corresponds with the red rock of the barren downs which succeed the blue slate at Prince's Common, and elsewhere; it is traversed by a large *elvan-course*, which (948.) is a coarse compact-felspar with disseminated crystals of iron-pyrites: No. 949, is the same decomposing. At the eastern extremity of this mine the zoned and variegated shorl-rock (950.) is very abundant; according to the miners it does not here form the *lode*, but beds or floors near the *lode*: it is very probable that nearer the granite the slate rocks may be of a similar nature to those of the Fat Work mine near Indian Queens.

Between Sithney and Helston, the country consists of hornblende-slate, (951.) which, at Sithney Green, contains (952.) a fine-grained granitic *elvan*.

FROM HELSTON TO PORTLEVEN, TREWAVAS HEAD, PRA-SANDS, AND CUDDAN POINT.

Around Helston, hornblende-rocks, both massive and schistose, prevail:—Nos. 953, 954, are from the hill beyond the western turnpike.

Similar kinds of rocks, becoming more fissile and finer grained, as you recede from Helston, continue to Portleven, as in the following specimens Nos. 955, 956, 957, 958, 959, 960, the two last of which are from the right side of Portleven Harbour.

At Tremearne, about a mile and a half north-west of the last place, a deep and narrow valley runs down towards the sea; the access to the cliffs is by a narrow path cut through the bed of diluvium that reposes on the rocky stratum. Turning to the left round the nearest point of the cliff, the rock is excavated by the sea into a deep but narrow chasm, in the direction of a soft decomposing lode; the rock itself is also much disintegrated, and is stained at the joints, and in patches, by the oxidation of iron-pyrites: it is a kind of felspar-slate (961.) of a light blue, with dark coloured spots, like that near granite so often described, and it is glossy from innumerable specks like mica. Nos. 962, 963, are specimens of it, in different stages of decay. Some parts of this rock (964, 965.) are of a finer grain and more fissile. It is traversed by numerous quartz-veins which are exceedingly tortuous in their course.

Near the descent from the cliffs, the rock (966.) is more compact, separating into thick laminæ: it exactly resembles the schistose rock next the granite, at Wheal Vor and Dolcoath.

The granitic veins are not, in composition, like those of Dolcoath; but partake more of the nature of the prevailing variety of the adjoining hill, which is a continuation of that of Tregonning. The small veins (967.) are generally harder than the large ones, owing to the predominance of granules of quartz intimately intermixed with minute particles of felspar and talc: sometimes shorl is present, (968.) and then this granitic stone is much harder than the

preceding. The large veins consist of a fine-grained talcose granite (969.) which becomes (970.) yellowish on decomposition;—it is also traversed by short irregular veins, in which the felspar, quartz, and talc, occur in large crystallized groups, the first mineral in particular (971.) being well defined. The middle part of these veins are most granitic, and that of the largest veins (972.) cannot be distinguished from the granite of the main mass.

At the brow of the hill, west of Tremearne, and opposite a little creek at Trequean, the granite (973.) projects, and is on a line with the head-land between this place and Trewavas Head: this rock (974.) differs from the last, its talc being of a deeper yellow, and not in crystalline scales. At Trewavas Head, the granite (975.) is harder, and more like the Breage stone:—it forms magnificent cliffs. Immediately under Rinsey a patch of felspar-slate (976.) lies on the side of the granite, as at Tremearne; and exhibits similar phenomena: it extends round the head-land as far as the village of Pra, where the granite projects in large scattered masses, giving this place a wild and alpine appearance.

An immense bank of siliceous sand skirts the shore between Pra and the other side of the cove, where the land runs out into Peden-due Point: in a little recess, not far from Pengersick, the hornblende-slate (977.) is intersected by an *elvan-course*, which lies west of north, and east of south, dipping N. E., at an angle of 45°. This *elvan* is a felspar-porphyry, which (978.) in the middle resembles a coarse por-

phyritic granite, the crystals of which are flesh-coloured:—next the slate it is composed almost entirely of (979.) compact-felspar; and the slate itself, in immediate contact with the latter, is (980.) very much intermixed with quartz, the same as in the case of the *elvans* near Penzance;—the last kind is succeeded by No. 981, which completes the transition into the hornblende-slate, No. 977.

Peden-due consists of hornblende-rocks, (982, 983, 984.) similar to the last: which are succeeded by the felspar-rocks of Cuddan Point, (985, 986.) abounding in veins of actynolite, and resembling the Lariggan rocks, near Penzance.

Before concluding the account of this district, I must observe that I did not carefully examine, nor obtain specimens from, that part included between Truro, Chasewater, Gwennap, and Mylor. There are, however, in the Museum a well selected series of specimens illustrative of the western portion of it, presented by Mr. W. M. Tweedy: amongst these, are many varieties of felspar-porphyries; some of which far exceed in beauty any that I have met with, having perfect crystals of felspar, and of quartz.

It may have been observed, that I have seldom noticed the phenomena of metalliferous veins: I purposely avoided this subject, because Mr. Henwood, who is engaged in a survey of the *lodes* of Cornwall and Devon, will personally obtain that information, for which I must have been solely indebted to the *Captains* of the mines.

CHAP. IV.

ON THE GEOLOGY OF THE LAND'S END DISTRICT OF CORNWALL.

THIS District comprises that part of the county, which is bounded by the Carnbrea District on the east, and on all other sides by the sea: it is less in superficial extent than either of the other districts; but it yields to none in geological interest, exhibiting numerous sections at, or near, the junction of the granite with the slate.

Accounts of various parts of this district have constituted the principal contents of the Society's Transactions: I shall not, therefore, enter into details on this subject, as it would occasion needless repetitions; but shall only make a few general remarks.

The greater part of this district is composed of granitic rocks, the boundaries of which have been accurately laid down by Dr. Forbes, with the exception of a projecting portion at Gunwin Point, between Lelant and St. Ives, as first noticed by our Secretary, Mr. Giddy.

"This granite" observes Dr. Forbes,* "being an unstratified rock, containing no subordinate beds,

* Vol. II. p. 248.

and never being found to alternate with any of the rocks contained in the other formations, offers little variety to excite curiosity or research." To these remarks I cannot assent: for the granite of this district, on the contrary, abounds in variety, and in interesting phenomena; much more so, indeed, than the granite of any other part of Cornwall.

Mr. Carne has minutely described the numerous granitic veins at the *junctions*; has recorded several instances of *granite veins* in granite; and has pointed out the alteration which granite experiences, in its composition, where it is in contact with quartz-veins: he has also given an account of two "granitic elvan courses" in the granite, which appear to me to deserve particular attention: one of these at Mean, in Sennen, is seventy feet wide, running nearly north and south; the other at Bosava, in Paul, is a regular channel of much greater width, and "it appears to be bounded at both ends, as well as on each side, and may, perhaps, be considered as a mass of a peculiar kind of granite in the midst of a granitic country, with as much propriety as an *elvan-course*."* In the preceding pages I have mentioned several places, in the various districts, where peculiar granitic rocks are contained in the common granite in distinct beds, after the manner of porphyry in the slate; and which are highly inclined, but which (as is also the case with the different strata of the schistose rocks) are not always continuous for any considerable distance. This I believe holds good with the granite

* Vol. III. p. 243.

will be of essential service to the Society, by furnishing an outline which may be corrected and filled out by those Members, who otherwise might not have been induced to record their observations.

In concluding the account of my survey, I take this opportunity of expressing my obligations to Mr. Rosevear, of Boscastle, for his hospitality and other kind services, whilst in his neighbourhood: I have also to acknowledge the polite attentions of Mr. Sloggatt, of the same place; of the Rev. Henry Coulson, Rector of Landewednack; of the Rev. Canon Rogers; and of the Rev. Samuel Trist, of Veryan. And, lest this short list of acknowledgements, after such long excursions, should lead any one to think that cornish hospitality is on the decline, I must in justice state that I received many and urgent invitations, even from strangers:—but I soon learnt that such intercourse, though very agreeable, interfered too much with the object in view. I accordingly avoided society altogether; and applying to no one for information, contented myself with examining such objects as came in my way, and which, in a country like Cornwall, could not fail of being both numerous and interesting. Without doubt, on this plan, many important facts have escaped my notice; but these deficiencies will, I trust, be compensated by the other Members completing the survey of their respective neighbourhoods.

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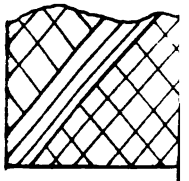

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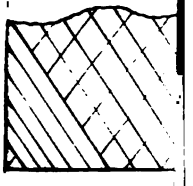

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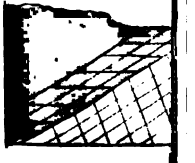

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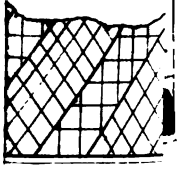

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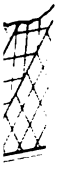

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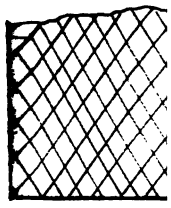

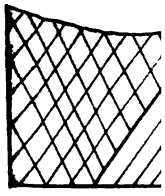

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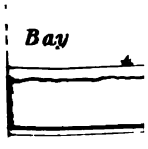

CHAP. V.

GENERAL OBSERVATIONS ON THE GEOLOGY OF CORNWALL.

HAVING described the Cornish rocks according to ir geographical positions, it is now proposed to empt a classification of the same;—to ascertain ir geological relations towards each other;—and discuss some theoretical subjects, suggested by e facts already recorded.

Cornwall is almost entirely composed of primary cks, which have been generally divided into the anite and slate formations: but this term, formaon, is not strictly correct, (as will be seen in the quel) because it implies a distinction which does ot exist in nature; it is, however, often convenient be able to refer to these individually, and it is, herefore, proposed to call them the granitic and chistose groups of the primary class. In addition o these, Cornwall also contains two small patches of derivative or fragmentary rocks: one, consisting of conglomerate and greywacké, at the Nare, in Helford Harbour; and the other, of red sandstone, at Cawsand;—both of which belong to the epoch of the

Plymouth or mountain limestone. The county affords no example of the more recent formations, with the exception of the diluvial and alluvial deposits.

The granite of Cornwall occurs in eight insulated groups; four of which are much larger than the others, and are situated in the centre of their respective districts. The smaller groups have been supposed, by many geologists, to have had a different origin from that of the larger ones: the granite of St. Michael's Mount, in particular, has given rise to much controversy; and concerning that of Cligga Point, near St. Agnes, the Rev. Mr. Conybeare* has observed, that it would probably be considered by the Wernerian school, as a newer formation. I cannot, however, see any good reasons for this opinion: these groups differ, indeed, very materially from each other in point of size, but the smallest of them, at their junction with the slate, exhibits the same phenomena as the largest; so that it is reasonable to conclude, that all the groups have the same origin.

It has also been generally stated, that the four principal groups of granite are situated on a line drawn from Launceston to the Land's End: but, on reference to the annexed map, it will be seen that such a line will not touch the granite of the central district, and only pass through the extreme northern part of that of Carnbrea; and the departure therefrom will be still more evident, when we regard the whole of the Ocrynian range, including the granite of Dartmoor, and of the Scilly Islands.

* Trans. of the Geol. Society of London, Vol. IV. p. 402.

Perhaps it may be deemed too fanciful, but it appears to me that these groups of granite are not parts of the same range, but belong to three distinct ranges, all lying parallel to each other, and running north-east and south-west; a direction common to the adjacent strata, and to the principal metalliferous veins. On this view of the subject, the first or northern range would correspond with a line drawn through the Scilly Isles, the Land's End, and Cligga Point;—the second or intermediate one would include the granite of the eastern, central, and Carnbrea districts; and the third or southern one would run through the granite of Dartmoor. On the north of these, a range may also exist at Lundy Island; and on the south, another at Eddistone: and the granitic ranges of Scotland, and of Brittany are said to have similar bearings.

If the existence of these minor and parallel ranges were established, it would explain the occurrence of crystalline rocks at a considerable distance from the central granite, though similar to those in its vicinity. It is, therefore, not improbable that the sienitic rock of Arthur's Castle, (resembling that of Davidstow,) and the felspar-rocks of Trevose Head, and Stepper Point, may be near granite; for they are not far from the line of the northern range. In like manner, the mining district of St. Agnes, though remote from the central granite, indicates that this rock is not far distant; which is actually proved by a mass of well characterized granite protruding at Cligga Point. These parallel ranges would also explain another in-

teresting circumstance; viz. on proceeding north or south from a central patch of granite, the slate for several miles dips from that rock; but it suddenly inclines from an opposite point of the compass, and retains its new direction until it is lost in the sea. May not the slate, having this reversed inclination, be the termination of another series of rocks which conformably recline on the granite, belonging to a parallel range? This solution will likewise clear up some of the difficulties regarding the nature of the Lizard serpentine: for if the diallage-rock be the equivalent of granite; or if a mass of this rock exist south of the Lizard as a continuation of the Dartmoor range, we have a reason why these strata dip towards the centre of the district: and why these crystalline rocks succeed, and are apparently superior in order, to strata containing limestone. This idea of several parallel ranges suggested itself, since the completion of my survey: it is an interesting speculation, and may lead to farther enquiries.

The granitic patches of the several districts, undergo a gradual declension in height, from the north-east to the south-west;—thus, the granite of the eastern district is the most elevated, and that of the Land's End the lowest: the line of their junction with the slate follows the same order; so as in the one case to attain a height of nearly 1,000 feet, and in the other to be often below high water-mark. And this holds good as far as the Scilly Isles, where the land is so depressed that granite is the only

rock that makes its appearance. It is probable that the space between these Isles and the Land's End, celebrated in legends under the name of the Lionesse, did once exist as dry land; two causes having tended to its submersion: one, the gradual degradation of the soft schistose rocks; the other, the periodical elevation of the sea-level. The period, however, at which this took place, must have been long anterior to the earliest tradition; unless other causes, than those now existing, have been in operation.

It is worthy of remark, that the fertility of these granitic groups gradually increases as they diminish in elevation; and in confirmation of which, I may point out the curious, though not surprising, coincidence, that the number of parish-churches thereon follows the same order: thus, in the Eastern District, there is only one church situated on the most extensive tract of granite; in the Central, there are three on this rock; in the Carnbrea, six; and in the Land's End District, no less than nine.

It is the general opinion that the several groups of granite incline towards each other, and are, at some unknown depth, all united into one common mass; the intermediate hollow spaces being occupied by the schistose rocks. Thus, the insulated groups of granite resemble, in some measure, the summits of mountains elevated above an ocean of slate which fills their valleys. This opinion is supported by the facts, that at the junction, the granite is seen to dip under the slate at a considerable angle, seldom less than 40°. or 45°.: and that, in mines several hundred

yards therefrom, this rock is also found at a great depth under the slate, having a similar inclination. The granite has not been penetrated into in the mines remote from the junction; nor is this to be wondered at, for no mine has been sunk so deep as five hundred yards; whilst the slate, allowing an inclination of 40°. to the granite, must in many places exceed three miles in depth; a measure which is very insignificant, when compared with the diameter of the globe; but which is immense, as regards the operations of man.

It must, however, be confessed that, although this hypothesis is plausible, it is not free from objection: and I rather incline to the doctrine of Professor Jameson, that granite consists of insulated masses imbedded in the schistose rocks. The spherical structure of granite, as developed in its individual blocks by the action of the elements, appears to be common to the whole mass; for wherever an extensive surface of its layers is exposed, as in quarries, it uniformly exhibits a considerable curvature. But the principal support of this opinion is derived from the circumstance, that masses of granite are found in the slate near the junction; and, even at the distance of two or three miles therefrom, as in the Herland mines, in the parish of Gwinear. It is, perhaps, almost superfluous to observe, that the curved side of the granite would continue to extend under the slate far beyond the limits of mining ope-operations; so that the occurrence of granite in the mines, near the junction, can form no objection to

this hypothesis. I have not yet been able to put the conjecture to the test of measurements; but it appears to me very probable, that several of the mines which are entirely in slate, ought to have reached the granite, even allowing this rock a considerable inclination. This subject deserves the particular attention of the Society: and it may be hoped that Mr. Henwood's extensive survey of the mines will throw some light thereon.

Before describing the varieties of the granitic rocks, and their geological relations, a few preliminary remarks will be offered; in order, to shew the necessity of extending the present nomenclature of primary rocks; and, to explain the grounds of some innovations which I have ventured to propose for the consideration of geologists.

All who have explored and studied primary districts, must have experienced the difficulty of recording their observations, on account of the paucity of names. In common with others I have also felt this; and in the preceding pages, I had only the choice of being deemed superfluously tedious, or of resting satisfied in describing Cornwall, as composed of granite, greywacké, clay-slate, and serpentine:—terms which have become so indefinite from their extended signification, that they cannot convey an accurate idea of the individual rocks.

The French geologists have endeavoured to obviate this defect, by multiplying distinctions, founded on mineralogical characters: but in this country there appears to be a great disinclination to adopt a plan

which has been rather uncourteously derided as *gallic neology*. Can there, however, be any doubt that a better discrimination of the primary rocks would lead to more accurate observations, and tend rather to promote, than retard, the progress of the science? It may also be asked, has any disadvantage arisen from the introduction of the term shorl-rock? and yet its geological relations are precisely the same as the granite with which it is associated. It is singular that Dr. Mac Culloch, who has written so much against the arrangement of rocks on mineralogical distinctions, has, in his classification, given a copious catalogue founded on this principle: and, that he has, notwithstanding his great dislike to *neology*, enriched our nomenclature more than any other British geologist, with names derived from the mineral composition of the respective rocks.

From this it follows that what is not good in theory, may be expedient in practice: and I purpose, therefore, to suggest names for such undescribed rocks, as exhibit distinct characters.

One of the objections that has been made to an enlarged nomenclature is, that the primary rocks exhibit such endless varieties during their gradual transitions into each other, that to provide names for all, would produce an endless multiplication. To this it may be answered, that the mineral kingdom is, in this respect, precisely similar to the other departments of Nature; which, respectively, have long and advantageously possessed a copious nomenclature. The mineral kingdom, however, or rather

that portion of it (the primary rocks) which has experienced no secondary changes, offers the greatest facilities for classification. For it is only by the accumulated labours of successive generations that animals and vegetables have been ascertained to form continuous chains, each link, or genus, of which is made up of numerous coalescing species; and it is only in the cabinets of the learned that they are to be seen thus arranged: whilst the different members of the primary rocks occur side by side, according to their affinities, already classified in the Museum of Nature.

Impressed, therefore, with a conviction that there is no insuperable obstacle to our obtaining a good classification of rocks, I will proceed to sketch a plan,

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AN ATTEMPT

To describe and classify the Cornish Rocks.

THE Rocks of Cornwall, like those of the whole EARTH, admit of a two-fold division: viz. into the Primary or Granitiferous, and the Secondary or Derivative, Classes. Cornwall is, however, composed almost entirely of the former class.

I.—GRANITIFEROUS CLASS.

This class comprises various series of massive and schistose rocks, which are not fragmentary, nor fossiliferous; and which are always (in their original position) inferior to those of the secondary class. The massive rocks are, for the most part, composed of several crystalline minerals; and are surrounded by, or imbedded in, the schistose; into which they pass by gradual transitions; and in which the constituents are no longer visible, being generally so intimately united as to form a homogeneous mass: so that, "the primary slates are, in their mineralogical composition, only varieties of the crystalline masses, with which they are largely and closely associated."

on which, I think, that this may be accomplished: and shall feel amply rewarded if I only succeed in directing the attention of geologists to this important object, which it appears to me will "simplify rather than confuse geological details." Wishing, however, at the same time to express that the arrangement, about to be proposed, is professedly in a very imperfect state, I have separated it from the text in the form of an appendix. On reference to the Map, the extent and situation of the granitic and schistose groups will be seen; and the position of their respective genera is illustrated by the sections.

The same varieties of granitic rocks do not occur in the central groups of each district; or rather it should be said, that they have not been detected: this may be attributed to circumstances unfavour-

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Each of these primary series has some peculiarity in its composition, which often occasions great dissimilarity of rocks in different parts of the world; and by which these series may be respectively characterized. Thus, the primary rocks of Aberdeenshire, abound in hornblende; those of the Alps and Corsica, in talc; and those of Cornwall, in shorl: these, therefore, constitute distinct and natural *formations*.

SHORLACEOUS OR OCRYNIAN FORMATION.

Under this head the primary rocks of Cornwall and Devon (and, perhaps, of some other countries) may be arranged. The Ocrynian formation is not only distinguished by containing shorl, but also by a great excess of felspar, which (either as a simple mineral, or in that compound form, called compact-felspar) forms the principal constituent in nearly all its rocks:—mica is very sparingly diffused; and thence the absence of gneiss and mica-slate, which are so abundant in many countries.

For the sake of facilitating description, this formation may be subdivided into the *granitic and schistose groups*.

able to research; for it so happens that the eastern district, which has been least explored by mines and quarries, affords fewer kinds than either of the others.

That kind of granite which consists of felspar, quartz, and mica, and which offers the most perfect example of this rock, according to its usual definition, is the variety most abundant in Cornwall: and is common to the central masses of each district.

Those kinds, in which the mica is wanting, or its place supplied by another mineral, it is proposed to separate from granite and to place in a distinct genus: thus rendering it essential for true granite to contain felspar, quartz, and mica.

The varieties of granite, thus restricted, are those usually enumerated: viz. 1st, those arising from the size of the granules; 2nd, those containing, besides the indispensable constituents, one or more adventitious minerals.

Granitic Group.

The rocks of this group are, for the most part, collected together into several insulated patches, encompassed on all sides by the schistose group; in which they also frequently occur in the form of beds, commonly called *elvan-courses*.

Genus 1. Granite. A massive crystalline rock, composed essentially of felspar, quartz, and mica; sometimes with one or more adventitious minerals: all of these are confusedly aggregated together, but are respectively visible in the mass.

G. *common*. All the constituents in moderate sized granules, seldom so large as a pea. It is not very prone to disintegration, and on this account is well adapted for building. *Localities*. Brown-Willey. Carn Grey. Kit Hill. Stithians. Mabe. Constantine. Madron.—In short, it occurs in all the districts.

G. *large-grained*. Granules much larger than the last, oftentimes in coarse concretions. *Local*. Carn-Marth. Cligga. Carnbrea. Carnkie. Wendron. Madron. St. Just.

Talc and shorl are the minerals which in Cornwall have occasionally usurped the place of mica; as hornblende has in Aberdeenshire: these compounds form beds of considerable extent, and are distinctly characterized. That into which talc enters, is peculiarly liable to undergo an extensive disintegration, giving rise to the china-clay of the central district, and of Tregonning Hill. Rather than invent a new name, I propose to call this compound *protogine*, a term which has been applied by the French to the talcose granite of the Alps.

G. *fine-grained*. An uniform mixture of granules much smaller than in the *common*. *Local*. Rough-Tor. Castle-an-Dinas. St. Michael's Mount. Wendron. Breage.

G. *porphyritic*. Large crystals of felspar in a basis of either of the former. It is of frequent occurrence. *Local*. Rough-Tor. Brey. Carraton. Beam, near Hensborough. Carn Grey. Cligga. Wendron.

G. *shorlaceous*. All large masses of granite contain some minute particles of shorl; but by shorlaceous granite is here understood that kind in which this mineral is a conspicuous ingredient. It is most abundant near the junction of the granite and the slate. *Local*. Between Carclaze and Carn Grey. Hingston Down. Abounds in the parishes of St. Dennis and St. Stephens: and on the borders of the Land's End granite.

G. *micaceous*. Mica in larger proportion than usual, imparting a glossy appearance, and a somewhat lamellar structure. *Local*. Near Penryn. Constantine. Ludgvan.

G. *pinitic*. Containing crystals of pinite. *Local*. Ninnis, Trendannack, Tol-Pedn-Penwith, and other places in the granite of the Land's End District.

Gen. 2. PROTOGINE. A compound of felspar, quartz, and talc, with the occasional intermixture of some other mineral, not mica. These minerals are crystalline, and aggregated together after the manner of granite: from which rock it is distinguished not only in the substitution of talc for mica, but also in its great tendency to disintegration. Analysis would probably shew that its felspar differs, in composition, from that of true granite, as talc does from mica.

P. *porcelaineus* (china-stone). Composed solely of felspar, quartz, and talc, which is of a greenish yellow colour. This rock affords, by decomposition, the china-clay of commerce: it is difficult to obtain a perfect specimen, its felspar being more or less earthy. *Local*. Common in the parishes of St. Stephens, and St. Austle. Tregonning Hill, near Breage.

The rock in which shorl occupies the place of mica, may be considered as a variety of *shorl-rock:* and as such it will be found in the appendix, where the different kinds, and the localities, of this interesting rock are enumerated.

P. *shorlaceous.* Similar to the last, with the addition of variable proportions of shorl. When decomposed, however, it is unfit for the potteries, being much stained with rust-coloured spots. It abounds in veins of quartz and shorl, which are rich in tin-ore. *Local.* St. Stephens. St. Dennis. Carclaze.

P. *fluoric.* Differs from the *porcelainous* in containing fluor-spar; and it is more crystalline and durable. *Local.* Near St. Stephens Beacon.

P. *porphyritic.* A basis of the shorlaceous kind, containing crystals of flesh-coloured felspar. *Local.* Near St. Stephens Beacon, and Watch Hill.

P. *quartzose* Fine grains of quartz predominating, the felspar and talc seldom entirely distinct, but mutually blended, producing a kind of yellow talcose felspar. *Local.* Tregonning. Breage. Trewavas.

Gen. 3. SHORL-ROCK. Is composed of quartz and shorl, with the occasional addition of a third mineral. Its species generally possess the structure of granite: but sometimes the constituents are so intimately blended that they cannot be distinguished, forming homogeneous substances which, however, are so well characterized, that they cannot easily be mistaken for any other rock. Shorl-rock occurs in distinct beds, but more commonly in immense veins: in both forms it is found in granite, and in protogine; and also amongst the schistose rocks.

* *Constituents distinct and crystalline.*

S. *granular.* Consisting of granules, uniform in size, which seldom exceed that of swan-shot. *Local.* Roach-Rock.

S. *large-grained.* The constituents very large and crystalline; sometimes the quartz, and sometimes the shorl, predominating. *Local.* Jolly Mill, near St. Dennis. At the junction in the parishes of Madron, Sancreed, & St. Just.

S. *fine-grained.* The crystalline granules smaller than the first, and which gradually become so fine as not to be discerned by the naked eye. *Local.* Near Carclaze. Borgotha. Madron. Sancreed.

S. *granitic.* This contains crystals of felspar, and in every respect resembles granite, except in wanting mica. It generally occurs at the junction: and abounds in veins and beds of the other species. *Local.* Kernick. Borgotha. St. Dennis. Madron. Sancreed. St. Just. Buryan. Sennen.

S. *quartzose.* A basis of crystalline quartz, throughout which crystals of shorl are disseminated in various proportions. *Local.* St. Mewan's Beacon.

The next kind of granitic rock to be noticed, often occurs in distinct beds, and is generally called fine-grained granite: but this is not correct, for though it may have the same elements as granite, yet these are not in the same crystalline state, nor are they similarly aggregated together. It comes nearest to the *eurite* of the French; and, therefore, for the present this name will be adopted.

** *Constituents intimately blended.*

S. *compact*. It exhibits various colours, from dark brown to light blue; it is hard and very brittle. It almost always accompanies the quartz *lodes* in, and near, the granite: and often forms large *elvan-courses*. *Local*. Carraton. Kit Hill. Carnkie. Cligga. Trevaunance. And in the parishes of St. Austle, St. Stephens, St. Dennis, Madron, Sennen, St. Just, &c.

S. *zoned*. Similar to the last, but exhibits various colours in straight stripes: these are generally dark and light blues, and sometimes white, which is entirely of quartz. *Local*. Borgotha. Jolly Mill. Sancreed. Sennen, &c.

S. *agate-like*. As the last, but the stripes variously waved and contorted. *Local*. Tregoss Moors. And near the junction in Madron and Sancreed.

S. *porphyritic*. A basis of the blue *compact*, including crystals of white felspar. *Local*. Near Carnkie.

Gen. 4. EURITE. A massive granular basis, throughout which grains and crystals of other minerals are sometimes disseminated. The basis appears to be composed of felspar and quartz, so united, that they are not to be distinguished by the eye; and it assumes different characters, according as one, or other, of these minerals predominates:—when felspar abounds, it is prone to decay; and when quartz, it is very hard and durable. It has been commonly called fine-grained granite; but, on this arrangement, this term is confined to that rock in which the constituents are all distinct and crystalline. It traverses true granite in the form of beds or *courses*: and is also of frequent occurrence amongst the schistose rocks.

E. *compact*. Consists almost solely of the basis, with some granules of quartz, and a few scales of mica. *Local*. Tremagenna. Creag Braws. Houghton Downs. Between Stithians and Penryn.

E. *porphyritic*. The *compact* containing crystals of felspar. *Local*. Polgooth. North-west of Sticker. Houghton Downs.

The next and last rock of the granitic group includes felspar-porphyry: but as this rock, in its most perfect state, seldom occurs except in the mid-

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E. *granitic.* Abounding in crystalline granules of felspar and quartz, with scales of mica; so that the basis is sometimes scarcely visible, in which case it approaches near to fine-grained granite. *Local.* Sithney-green. Pentewan. Pancarrow, near Camelford. Kit Hill.

E. *shorlaceous.* Grains and crystals of shorl scattered throughout the basis. *Local.* Hanover quarry, near Cligga.

E. *hornblendic.* Like the last, hornblende being substituted for shorl. *Local.* Kernick, between Bodmin and Camelford. Carraton Hill.

E. *porcelainous.* The *compact* having a greenish yellow colour, probably from an intimate combination of talc, like that in the porcelainous protogine. It decomposes into a white mass, very similar to prepared china-clay. *Local.* About one mile from Bodmin, on the road to Truro.

Gen. 5. FELSPARITE OR FELSPAR-ROCK. This rock differs only from Eurite in its basis being compact and crystalline: it likewise occurs as beds traversing both the granitic and schistose rocks. Its principal *species* is well known under the name of felspar-porphyry.

F. *compact.* Consists almost solely of the basis with granules of quartz, and a few scales of mica. *Local.* Resugga Downs, between Grampound and St. Stephens. Swan Pool. Wheal Vor. Dolcoath. Cardrew. On the shores of Mount's Bay, common.

F. *siliceous.* The quartz of the compound basis so predominating, that the felspar is almost entirely wanting; as shewn by its durability. *Local.* Cook's Kitchen. Swan Pool. Wheal Vor. Shores of Mount's Bay, and elsewhere; generally situated between the *compact* and the slate rocks.

F. *shorlaceous.* The *compact* abounding in grains, and minute crystals of shorl, which are often arranged in radiated crystals. *Local.* Mean. Near the Logan Rock. Rosemodris. Bosava, in Paul. Tregonnebris Hill.

F. *porphyritic.* Distinct crystals imbedded in the compact base. *Local.* Poldice, near St. Day. Dolcoath and Cook's Kitchen. Between Stithians and Penryn. Trumpet Mine, Wendron. Rosemorran. Long Rock and Chimney Rock, in Mount's Bay: also near Pengersick.

F. *granitic.* The accessory minerals predominating over the base, so as to resemble granite. *Local.* Davidstow-Moor. Dolcoath and Cook's Kitchen. Wheal Vor. Between Marazion Mines and Ludgvan.

F. *chloritic.* Its basis is generally very quartzose, containing variable proportions of dark crystalline chlorite. It is very commonly accompanied by irregular patches and veins of tin-ore: and frequently passes into compact shorl-rock. *Local.* Near the junction of granite with the slate, (in both rocks) in the parishes of Gwennap, Wendron, Breage, Madron and St. Just.

dle of the bed, it ought not to give its name to the whole mass, though it is certainly the most conspicuous member of the genus. All the varieties of this rock have, in common, a basis of compact-felspar, (that is, a compound of felspar and quartz,) which assumes various characters, passing gradually from crystalline felspar into hornstone, and even into quartz, according as one or other of its constituents predominates. This genus may, therefore, be called *felspar-rock* or *felsparite.*

Such are the granitic rocks of Cornwall: and those that are peculiar to other formations will readily suggest themselves to the geologist; and they may be easily classed according to the annexed arrangement, if this should be approved of.

In the foregoing outline, I have adopted names now in use, and have endeavoured to keep as close as possible to their usual application: so far the task has been comparatively easy; but in extending this plan to the slate group, much greater innovations will be necessary.

The geological relations of these granitic rocks towards each other are various: sometimes one kind occurs imbedded in another in the form of irregular patches, or in distinct spheroidal concretions, composed of concentric layers; and sometimes several varieties may be found contiguous to the large quartz-veins which traverse each of the granitic genera:—but all of these are of very limited and partial occurrence.

This variation in the composition of granite, immediately in contact with quartz-veins, is of such frequent occurrence in every part of Cornwall, that it merits particular attention: and it is very interesting in a theoretical point of view. Mr. Carne,* in his account of the granite of the western districts, has made some good remarks on this subject; the whole deserves a careful perusal, but I shall only quote the following passage. "The granite close to the (quartz) vein generally contains more felspar and less quartz than the granite mass near it. It is possible, therefore, that at the period of the formation of the granite, the matter of the quartz, instead of combining generally with the other substances, arranged itself, perhaps by elective affinity, in separate, although contemporaneous veins; and in consequence the granite close to it contains a smaller quantity."

These granitic rocks, however, are commonly arranged in distinct beds, which are highly inclined, and maintain a parallel course for a considerable distance: and which, collectively, constitute a mass, having a structure as regular (that is, disposed in as perfect layers) as the schistose rocks. That the granitic beds are sometimes comparatively short and irregular, does not destroy the analogy; for the massive rocks imbedded in, and alternating with, the slate, are often very capricious in their form, and of very limited extent. It may be also observed, that all these genera, perhaps, with the exception of true

* Vol. III. p. 214.—On the Granite of the Western Part of Cornwall.

granite, occur likewise amongst the slate rocks, and form some of their most regular beds: indeed, such beds are sometimes known to traverse both the granite and the slate.

Shorl-rock has, therefore, the same geological relations as the other kinds of granitic rocks; and since Cornwall offers, perhaps, the best field for studying its nature, some farther details on this subject may not be deemed altogether superfluous.

Shorl, as a constituent mineral, is present in the granitic patches of each district; but is more particularly abundant in the central and western districts: and in these, it appears gradually to increase in quantity, as the junction with the slate is approached. It has been already stated, that shorl sometimes becomes a conspicuous ingredient in granite and protogine, giving rise to the shorlaceous varieties; but, in these rocks, this mineral is more commonly in the form of small *strings* or *veins*, and of crystalline particles disseminated throughout the quartz-veins. The last mentioned rocks are often succeeded by beds of *granitic* shorl-rock; in which the quartz-veins are much larger than in the preceding, and are abundantly combined with shorl, giving rise to many varieties of *compact* shorl-rock. By the disappearance of its felspar, the *granitic* shorl-rock passes into the *granular* varieties of this genus, which are generally very conspicuous: for whilst the former (in consequence of the disintegration of its felspar) has crumbled down, and has been washed away by the rains; the latter, composed of more durable

materials, has withstood the action of the elements, and in the form of tors or carns, crowns the more elevated parts of the barren moors. These tors appear, therefore, to mark the extent of the depredations of the elements since the last deluge; for, although they may withstand the action of atmospheric agents, yet being divided into blocks by open seams and fissures, they would be overturned and hurled from their elevated position, whenever assailed by the torrents of a *debacle.*

All the granitic rocks, that contain felspar, are liable to decay: but of these, the *common* granite yields to none in durability; and thence it may arise, that the highest hills are composed almost entirely of this kind. Granite sometimes decomposes to a considerable extent, without losing its tenacity; as is seen in the excavations for gravel in the western district; some of which, near St. Just, have been appropriated as dwellings; the sides and roofs of which have the appearance of a coarse freestone.

That kind of granitic rock, for which the name of protogine has been proposed, is, of all others, the most extensively disintegrated; in which state it is provincially called *china-clay:* it abounds in St. Stephens, and the adjoining parishes, and in Tregonning Hill, near Breage; and affords an interesting subject for geological enquiry. The formation of this substance is generally attributed to decomposition: it must, however, be acknowledged that, if such be its origin, the elements have, in this instance, greatly transcended their usual operations.

Mr. Hawkins in a paper read at the last annual meeting of the Society, combats this opinion; and maintains, if I mistake not, that the present condition of these beds of clay is original, the lapidifying power having been arrested, or not as yet having extended so far upwards: coming from such respectable authority, this conjecture must be received with deference; but, I think, that, in this instance, our much esteemed colleague has drawn a wrong conclusion.

The gradual diminution in the cohesion of the particles from the solid rock upwards, will, of course support the opinion of either party. But it may be remarked, that the solid state of the one, and the disintegrated state of the other, is not the only difference; there is a chemical, as well as a mechanical, distinction; for the solid felspar contains an alkali, which analysis has not detected in porcelain-earth: and it therefore follows, since an alkali is not present in the perfect *china-clay* as a constituent part chemically combined, that this substance cannot, on account of its great solubility in water, exist in a free state in the mass of *china-clay*, which, in its native bed, is always wet; for by the constant percolation of water, it would be as effectually removed, as in the process itself, by which the porcelain-earth is prepared. It may also be observed, that the stained parts, which the workmen reject, under the name of *weed*, are of a yellowish, or red colour; indicating, that the iron, contained in the shorl or hornblende, has passed into a higher state of oxidation: in the description of these beds of clay,

it was noticed, that they were bounded by solid granite; and that they were traversed by large masses and veins of quartz, containing shorl: these circumstances furnish, I think, another argument against Mr. Hawkin's opinion; for it is difficult to conceive why the power, whatever it might have been, should have acted so partially in its operations, as to have consolidated one part of the mass, and to have left the other in a loose friable state. Again, the partially changed granite, called *china-stone*, will in time entirely lose its cohesion, as is seen in the numerous masses around the quarries; which, although they retain their form, immediately crumble into pieces on attempting to remove them. And, lastly, the analogy of other rocks affords, perhaps, the best proof that *china-clay* is a decomposed granite.

Admitting this derivative origin of porcelain-earth, an interesting question arises; viz. what can be the peculiar composition of this kind of granite, that renders it so preeminently subject to disintegration?

Mr. Carne* has observed that "the china-stone of St. Stephens might perhaps be mentioned as another variety of granite, but it owes most of its difference from ordinary granite to decomposition." This opinion prevails very generally, which is rather surprising, for this property of undergoing such extensive decay, is alone sufficient to indicate that it is a rock *sui generis*: besides it is peculiar in composition, containing talc instead of mica; which circumstance may afford a clue to the explanation.

* Vol. III. p. 212.—On the Granite of the Western Part of Cornwall.

Not that the talc itself, can be supposed to exert any direct action on the felspar: but, in consequence of its having been formed, instead of mica, in the original crystallization of this rock, the felspar may have experienced some modification in the proportion of its constituent parts, whereby it acquired the property now under consideration.

DESCRIPTION OF THE ROCKS OF THE SCHISTOSE GROUP.

The whole of the schistose group of Cornwall is one continuous mass: so that, in each of the four adopted districts, it entirely wants those natural boundaries which characterize the several groups of granite. The schistose group contains a greater variety of rocks than the granitic: and it well deserves the attention of the geologist, not only as being the grand repository of tin, copper, and other metals, but also on account of the frequent transitions of its rocks into each other, and the nature of its junction with the granite.

According to Dr. Berger* and others, these rocks consist principally of greywacké, and greywacké slate: whilst Professor Mohs,† on the other hand, states that he did not see any of this rock, in all Cornwall. Again, some geologists have represented this group to be composed of argillaceous schist or clay-slate: but such sweeping and general accounts

* Trans. of Geol. Society of London, Vol. I.—On Cornwall and Devon.

† Annals of Philos. Vol. XIII. p. 311.

convey but a very poor idea of its numerous and dissimilar rocks, with their respective varieties.

The most accurate description of Cornish rocks, that I have met with, is that of the Rev. J. J. Conybeare,* who has proposed to divide the schistose rocks into *inferior* and *superior*.† the former, "being cupriferous and stanniferous, and including various porphyritic and felspathic rocks (elvans), and occasionally greenstone;" the latter, "containing no elvans, but abounding much more in greenstone, especially in its obscurer varieties, and in dark coloured limestones; sparingly metalliferous, containing no tin, and more productive of lead than the inferior; and lastly containing occasionally organic remains." At the same time this able geologist has candidly admitted that this division of slates is purely arbitrary, as no such distinction exists in nature: but thinks that it may be adopted on account of its convenience.

To these sentiments I cordially subscribe, and approve of the two-fold subdivision; though in the details we do not entirely agree. In rocks that are so intimately united and blended together, and the strata of which often dip from opposite points of the compass towards each other, the terms *inferior* and *superior* are too theoretical: and it may, therefore, be preferable to call the former *porphyritic*, and the latter *calcareous*: affixing the word *series* instead of

* On Cornwall and Devon, Annals of Philos. new Series, Vol. V. p. 185.

† The same author also adds "stratified rock" as a third subdivision, but subjoins his opinion "that it might, perhaps, be regarded as forming the upper portion of the superior slate."

that of division:—thus, the porphyritic series will include that portion of the schistose group, in which felspar-rocks and porphyries abound; the calcareous series, on the other hand, will embrace all those rocks in which calc-spar is a frequent constituent, and which also alternate with limestone. No organic remains have been hitherto detected in these rocks; for, as has already been stated and this subject will be again reverted to, I cannot admit that the diverging striæ, in the slate of Tintagel, are attributable to the impressions of shells.

In attempting to trace these series on the map, great difficulties present themselves at every step; for these rocks pass into each other so imperceptibly, that even if they were entirely exposed to view, it would be no easy matter to lay down their boundaries accurately. I have, therefore, on the suggestion of my friend, Dr. Barham, blended the colours (which represent these series) at their point of contact, so as to imitate their natural condition.

The porphyritic and calcareous series have one character in common;—viz. that they respectively consist of two kinds of rocks: the one, has a slaty structure, and forms the greater portion of the whole; the other, is compact, and is generally imbedded in the former: both, however, mutually and gradually pass into each other. The compact is more crystalline than the schistose variety; and the minerals, of which it is composed, are frequently exhibited in distinct clusters. Thus Nature, as it were, proffers her own analysis to assist us in our

researches, by giving us an insight into the composition of those rocks, in which the elementary minerals are so intimately blended as to present only a homogeneous mass.

I was gratified to find this view of the subject confirmed by the previous observations of the Rev. J. J. Conybeare,* who had not only made a similar deduction, but proposed to found thereon the following general law; viz. "*that stratified rocks are in their mineralogical composition only varieties of the crystalline masses with which they are most largely and closely associated.*" This important observation has been either overlooked; or, perhaps, it has not been duly appreciated by geologists: for I find no mention of it in the works either of De la Beche, or of Dr. Macculloch, published during the present year.

Now these massive rocks, with their subordinate schistose varieties, form distinct members or *suites* of their respective series:—that is, each series is composed of several of these *suites*, which it is proposed to denominate genera. Each genus passes, on either hand, into the adjoining ones; and in its centre contains a distinctly characterized rock, which is generally massive, and oftentimes crystalline, and which may, therefore, be considered as its type.

On these principles, that which at first sight appears to be so intricate and impracticable, may be ultimately reduced, I think, to something like order, though in the first instance the attempt cannot be expected to be rewarded with complete success.

* Annals of Philosophy, new Series. Vol. VI. p. 37.

It has been already remarked, that the granite, in contact with quartz-veins, often differs from the main mass of this rock; and the same fact is also of common occurrence in the schistose rocks: as is well known in the roofing slate quarries, where the slate under such circumstances becomes less fissile, and even massive, with a conchoidal fracture. In taking specimens, therefore, it is necessary to bear this fact in mind, and to note their position, as well as their locality: otherwise an imperfect knowledge of a district may be communicated. To the experienced geologist, such cautions are needless; but to those who have not long studied this science they may not be altogether superfluous: for it frequently happens (I speak of Cornwall) that the portions of rocks adjoining quartz-veins, being the harder and more durable parts, are most frequently exposed to view, and therefore very likely to be resorted to for specimens:—that this has been the case in more than one instance may be seen in our own Museum; which is not singular in this respect.

Another precaution to be observed in ascertaining the different kinds of these rocks, is to examine whether they are as perfect as they, at first sight, appear to be; or whether they owe their peculiar characters to their having undergone a slight chemical change: some geologists, and those too, of no little note, have thus mistaken the nature of several Cornish rocks. The depth to which this change is partially effected, without destroying the structure or tenacity of the rock, is truly surprising; and,

in some cases, it is no easy matter to determine, whether the rock be perfect or not; since the country for many miles around may only afford shallow excavations: but the first deep quarry will probably prove, that many of the apparent varieties passed over in the neighbourhood, are the same rock in different stages of decomposition.

By carefully recording, therefore, both the position and the condition of the specimens collected, the varieties of the schistose rocks may be very considerably reduced in number: but even after all, the remaining rocks are so numerous, that it is difficult to arrange them, and still more perplexing to find names for them in the present inadequate nomenclature.

The first or porphyritic series is that which lies nearest to the granite. Its rocks are almost infinitely diversified; yet I think, that they will be all found to have a basis of compact-felspar, (that is, a compound of felspar and quartz,) which mineral, like all those that do not assume a crystalline form, is not definite in its composition, but is continually varying in the proportion, and in the mode of aggregation, of its constituents; and, therefore, assumes different characters, according as the felspar or quartz predominates, exhibiting all the intermediate shades between a crystalline compact-felspar, hornstone, iron-flint, and even quartz itself.

Sometimes these various forms of felspathic minerals constitute pretty considerable masses of rock; but more generally other minerals are distinctly imbedded, or intimately blended therewith; thus

affording a specific character, by which many of these rocks may be distinguished: these minerals are chiefly shorl, hornblende, chlorite, actynolite, talc, diallage, asbestus, and steatite. It must, however, be observed that the imbedded minerals, like the basis itself, do not often consist of definite compounds, as those just mentioned; but appear to be substances intermediate between some of these; one or more, perhaps, being intimately mixed together, or they may be minerals *sui generis* hitherto undescribed.*

On acccount, therefore, of this frequent variation in the nature, both of the base and of the accessory minerals contained therein, it is no easy matter to ascertain the composition of many of these rocks: and thence is the great difficulty of giving them appropriate names.

"The varieties and transitions," says De la Beche, "of the inferior stratified rocks into each other

* This mutual transition of minerals into each other, has been often noticed by Dr. Macculloch in his descriptions of Scotland: and on this subject I must again quote the Rev. J. J. Conybeare, and I have more pleasure in doing so, as my remarks, (written before I had seen his paper in the Annals of Philosophy,) serve to confirm his observations. "To the geologist, who seeks the aid of mineralogy and chemistry, examples of this intimate penetration of one simple mineral by another, (so, as in many cases, to alter very considerably the external and empirical characters of that which yet predominates,) must be familiar. Many subordinate beds of the earlier greenstone formation, exhibit every stage of a similar phenomenon, and an accurate examination would probably shew, that most of the substances named petrosilex, corneenne, sausurite, jade, and even flinty slate, are in fact only admixtures of this nature, in which felspar varying from its more compact and semi-transparent, to its earthy and granular form, is uniformly and intimately penetrated by some variety or other of hornblende, of diallage, and occasionally, perhaps, of other minerals, which (as hypersthene,) enter more sparingly into the composition of rock masses. Such admixtures can be properly studied only in those endless suites of specimens which Nature herself preserves, and presents in *situ*. The subject is an interesting one, and well deserves closer attention and investigation than it has yet met with."

appear endless; and, occurring in no determinate order, set classification utterly at defiance." "All this apparent confusion, and this passage of one rock into another, though it may embarrass arrangements, may be precisely the circumstances which may lead to some knowledge of the causes that have produced the lowest stratified rocks."*

The first rock of the porphyritic series, to be noticed, occurs next the granite; by numerous layers and veins of which it is generally traversed: it is, therefore, very interesting in a theoretical point of view, and demands particular attention.

This rock has been called by some geologists slate, clay-slate, or *killas;* but even the miners, from whom this last term has been borrowed, do not acknowledge it as a true *killas,* for I have frequently known them, when desirous of expressing the distinction, call it "a kind of *bastard or elvany killas.*" Others have described it as greenstone; and some have of late, agreeable to the present doctrine of the igneous origin of granite, considered it as slate indurated by its contact with granite, whilst this rock was in a state of fusion. The latter opinion will be discussed hereafter: but it may now be stated that although this slate is sometimes of little thickness, yet it frequently exceeds several hundred yards, which, in so bad a conductor, is a considerable distance for this process of induration to extend.

The rock, in question, exhibits various shades of dark blue and purple, sometimes of an uniform

* Geological Manual, p. 464.

colour, but occasionally with dark spots or patches on a light blue base;—it varies from hard to very hard, and breaks, though not easily, into thick plates full of joints; its surface is often spangled with a micaceous looking mineral, the parallel arrangement of which imparts to the mass a laminated structure: on decomposition, it becomes much more schistose, and of a dirty yellowish white colour. It is very probably a compound of compact-felspar, and a dark scaly mineral:* the former constituting the basis, with which the latter is intimately blended, imparting the colour; and throughout which it is also disseminated in scales or crystalline patches.

It appears, therefore, to constitute a rock, *sui generis;* which ought to be distinguished by a peculiar denomination;† and as it is exceedingly rich in tin and copper-ores (being the principal seat of the Cornish mines) the name of *cornubianite* might be adopted. *Cornubianite,* as already stated, occurs in conjunction with the granite: the latter, at the point of contact, is generally harder and more compact than at a distance therefrom; and both rocks oftentimes so firmly cohere together, that they cannot be

* Mr. Hawkins has given it as his opinion that the common *killas*, or slate of the mining district "is an intimate mixture of quartz, with mica, talc, chlorite, and perhaps in some instances with felspar." And Professor Mohs says that "killas is an intermediate substance between mica-slate and clay-slate, alternating with beds of porphyry, whose basis is an intimate mixture of felspar, quartz, and mica." Annals of Philosophy, Vol. XIII. p. 312.

† "The common *killas*" says the Rev. J. J. Conybeare," after much question as to its being a variety of greywacké, which, if that term has any definite meaning, it unquestionably is not, has been at last admitted on all hands to be a *genuine clay-slate*. But this appellation perhaps after all does not convey a much clearer notion of the real nature and constitution of the rocks included under it, than the repudiated greywacké." Ann. Philos. new series. v. VI. p. 37.

easily separated. It is also traversed by irregular beds, masses, and veins, of granitic rocks; which, however, are not true granite, but varieties of eurite and felsparite, which, in some parts, only are composed of crystalline granules, forming the *granitic* species of these rocks, as already described. The felsparite is of far more frequent occurrence than the eurite; and since it has the same compact basis as the cornubianite, it is not surprising that these rocks should be found gradually passing into each other, at Dolcoath, Trewavas, and elsewhere.

From these facts it may be concluded, that the cornubianite is composed of the same elements as granite, i. e. of felspar, quartz, and mica; the two first forming compact-felspar, which is interlaminated with mica: and, that it is in its nature intimately connected with granite, is confirmed by its containing rocks which are associated with, and form an integrant part of, the granitic group. Thus we find, that although it may be convenient to separate the granitic and schistose rocks in an artificial arrangement, no such distinction exists in Nature.

On this view of the subject, the nature of the granitic rocks of Dolcoath, and similar places, is easily explained:—whether they be lancet-shaped masses connected with the main body of granite, as conjectured by Professor Sedgwick; or, regular alternating beds, as reported by the intelligent *Captain* of this mine. And the obscurity in which the nature of granite-veins has been so long involved, is in a great measure expelled, on the supposition

that these are not only contemporaneous, but are also of similar mineral composition, with the laminated rock in which they occur.* It appears to me, that much of the perplexity of this subject has arisen from not having formed a due estimate of the mineral characters of the rocks in question; for they have been generally called granite, and slate or *killas*; names which convey an idea that these rocks are very dissimilar, and of distinct origin.

I must not, however, omit to notice the fragment-like pieces of slate, which are sometimes contained in the granitic veins, as they have been considered an insuperable objection to the opinion that the veins and the slate are of contemporaneous origin. These fragment-like pieces are indeed of the same nature as the slate, in which the veins occur; but it has already been shewn that these do not differ much in composition: this phenomenon may, therefore, be ascribed to the peculiar arrangement of the particles during the formation. The occurrence of fragment-like portions of minerals and of rocks is very common, both in metalliferous veins, and in the rocks themselves: several instances have been recorded in the preceding pages; and this subject will again come under consideration.

* The opinion of Professor Buckland on this subject is important. "The *elvans* all along the northern coast of Cornwall, occur in beds and veins of every possible thickness, from forty feet to half an inch, sometimes overlying but more frequently traversing the killas in various directions, under such circumstances as are apparently irreconcilable with any other theory, than that which supposes them to be of contemporaneous formation with the rock containing them; the result of some play of affinities which allowed a part of the mass to assume a crystalline texture, while its coarser and more abundant portions were left to arrange themselves in the slaty or tortuous form which characterizes the killas." Trans. Geol. Soc. of London. Vol. IV. p. 401.

Mr. Carne,* who has given the best and most extensive account of these granite-veins, has summed up the various opinions, that have been deduced therefrom; and considers, that if all these phenomena were subject to one general conclusion, the most reasonable one appears to be, "that the main body of granite may have preceded the slate, although the granite-veins (as veins) may have followed it." "Others," he says, "have cut the knot which they have found so difficult to untie, and declared the whole mass to be contemporaneous." But I trust that the facts, now adduced, will convince both Mr. Carne and others, that the view of the subject which has just been proposed, if not the true one, is the best adapted, in the present state of our knowledge, to explain this phenomenon.

* Vol. II.—On the Veins of Cornwall.

GRANITIFEROUS CLASS *(continued)*.

SCHISTOSE GROUP OF THE OCRYNIAN FORMATION.

The rocks of this group surround, at the surface, the several patches of granite, with which they are intimately connected, and into which they appear to pass, being composed of the same ingredients, only differently combined or aggregated.

They are traversed by numerous seams or joints, by which they are divided into layers: the slates are more or less undulating and curved, so that they appear to be variously inclined, but they always ultimately dip from the nearest central group of granite; whilst the granitic beds contained therein generally incline in a reverse direction, towards the central group, and at a much greater angle than the slate.

The schistose group may be subdivided into the *porphyritic* and the *calcareous series;*—though it must be remembered that this is purely artificial: for both series gradually pass into each other, so that no line of demarcation can be drawn in Nature.

In many parts of Cornwall the schistose rocks adjoining the granite, have a basis more granular than that of cornubianite; are much softer, and more prone to disintegrate: following, therefore, the plan adopted in the instance of eurite and felsparite, these may be referred to a distinct genus which, on account of the various appearances it assumes, may be called *proteolite*..

The opportunities for studying this genus, are not so favourable as in the former: for its junction with

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PORPHYRITIC SERIES.

Includes that portion of the schistose group, which occurs next the granite, which frequently contains porphyries and other granitic rocks in the form of regular beds or *elvan-courses*, and which abounds in veins of tin and copper-ores.

Gen. 6. CORNUBIANITE. Consists of a basis of compact-felspar, coloured by a dark mineral resembling mica, with which it is not only intimately combined, but also contains this mineral in distinct granules or scales variously disposed. This rock always occurs in contact with granite; by numerous beds and veins of which, it is frequently intersected.

C. *compact*. Consists principally of the base coloured by the intimate mixture of the accessory mineral, exhibiting various tints of blue and purple. *Local*. Poldice, near St. Day. Cardrew. Cook's Kitchen.

C. *quartzose*. Silica predominating gradually in its base as it approaches the the *elvans*. *Local*. Cardrew, near Redruth. Dolcoath. Wheal Vor.

C. *lamellar*. Differs only from the compact in separating into laminæ. It is often purple, and is then called by the miner *purple killas*. *Local*. Cardrew. Dolcoath. Wheal Vor.

C. *striped*. Has a blue basis like the lamellar, but is striped in consequence of the colouring mineral being wanting in the light coloured parts. *Local*. Lanescot Mine.

C. *micaceous*. Differs from the lamellar in having micaceous scales arranged parallel with the large cleavage. *Local*. Cardrew, near Redruth. Poldice, near St. Day. Dolcoath. Cook's Kitchen.

C. *schistose*. A blue slate, often of a light tint with dark spots: it forms the passage into other slate rocks. *Local*. Cardrew. Lanescot & Marazion mines.

the granite is not laid bare by the sea, nor is it explored by mines;—it having been ascertained that tin and copper-ores do not abound therein, which circumstance affords another distinction between cornubianite and proteolite.

It may be deemed advisable hereafter to separate this genus into several: but being desirous of avoiding innovation as much as possible, I have, for the

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Gen. 7. PROTEOLITE. This rock is, in composition, very similar to the last: but the ingredients are differently aggregated. Its felspar basis is granular, softer than the last, and more prone to decay. It contains tin and copper-ores; but these have not hitherto been detected in such quantities, as to be favourable to mining speculations: and, therefore, not being so much explored, its nature is not so well known as that of the cornubianite. It may be divided into two families: mica being the accessory mineral in the one; and shorl, in the other.

* *Containing mica, or a mineral nearly allied thereto.*

P. *micaceous.* Is very glossy; in the direction of its layers it shivers under the hammer into short irregular leaves, and on the cross fracture it is granular. It undergoes a partial but extensive decomposition. *Local.* St. Breward. Michaelstow. Cardinham.

P. *talcose.* More glossy and granular than the last: softer and somewhat soapy to the feel. *Local.* Castle Kenyoe.

P. *lamellar.* Breaks into thick rhomboidal plates, the surface of which is thickly spotted and bespangled with filmy scales of mica. *Local.* Near St. Blazey Bridge. Near Lostwithiel. St. Agnes' Beacon. Kerthen.

P. *striped.* Alternating laminæ of blue and white; the latter appear to be the basis of the rock free from the colouring mineral. *Local.* Trevaunance Cove.

P. *quartzose.* It is tabular, compact and very hard: the basis sometimes almost entirely siliceous. *Local.* St. Agnes' Beacon.

P. *schistose.* A blue fine-grained slate, rather fissile: it becomes of a light fawn colour on decomposition. *Local.* Smith's, Kernick, and Key Bridge, on the road between Bodmin and Camelford.

P. *siliceous.* Similar to the last, but harder and more siliceous: it is sometimes quite quartzose. *Local.* Baron Downs.

P. *argillaceous.* When perfect a thick laminated slate, soft, and of a pale blue colour: but generally in a state of partial decomposition, earthy in texture, yellowish white with ochreous stains. Used as a building stone. *Local.* Quarries around Bodmin.

present, subdivided it into two families;—one containing a mineral resembling mica; the other being combined with shorl.

One species of this rock particularly merits attention: it contains a large quantity of mica, (and may therefore be called *micaceous proteolite)* approaching nearer to mica-slate than any other Cornish rock; indeed it might, perhaps, by some, be considered as a variety of this substance, as it consists of granular-felspar, interlaminated with mica. It occurs in the immediate vicinity of the granite, which contains more mica than is usual; and follows the boundaries of this rock from Michaelstow through St. Breward, Blisland and Cardinham. At Penrose, on the Camel, near St. Breward, the hill is so steep, and this slaty rock rises so high on the granite, that the junction might be exposed at a trifling expense; and it would be interesting to ascertain whether the same phenomenon of granite-veins occurs here in this micaceous rock, as elsewhere in the cornubianite.

** *Containing shorl.*

P. *compact*. An uniform mixture of the constituents: it becomes of a light red on decomposition. *Local*. Castle-an-Dinas.

P. *striped*. Like the last, with curved and contorted stripes of a lighter colour, in which, perhaps, the shorl is wanting. *Local*. Fat Work Mine.

P. *amygdaloidal*. Minute rounded crystalline concretions disseminated throughout the granular felspar basis. *Local*. St. Stephens. Cligga. Roach.

P. *fragmentary*. A dark coloured and compact basis containing numerous angular pieces of the other species of this rock, which resemble fragments. It contains irregular veins of tin-ore: and on this account is called a *lode* by the miners. *Local*. Fat Work Mine, near Indian Queens.

P. *foliated*. Of an uniform blue colour with the slaty structure. It acquires a bright salmon colour when partially disintegrated. *Local*. Between Indian Queens and St. Columb Major. Cliffs between Trevaunance & Cligga.

The *micaceous* proteolite contains, at Penrose, a large bed of purple *compact* cornubianite; and near Cardinham a *course* of *porphyritic* eurite.

The next division of proteolite also occurs adjoining the granite; and is characterized by shorl, which enters into combination with the granular-felspar, instead of mica: the shorl, however, cannot be always detected in the rock.

The *amygdáloidal* proteolite is composed almost entirely of a light blue granular base, spotted with a dark mineral, like shorl, in the form of minute crystalline concretions: it is schistose; and is generally disintegrated to such a depth, that it is difficult to obtain a perfect specimen.

Near Kitt Hill, this rock contains a bed of *granitic* eurite; at Cligga, numerous *courses*, both of *granitic* and *porphyritic* eurite; and at Roach, a large mass of shorl-rock. The nature of the connection of the proteolite with these granitic rocks may be seen in many instances; and, except in the case of shorl-rock, their composition is so similar that the transitions are readily effected. The junction of the shorl-rock of Roach with the slate is not exposed: but, in the excavations on the adjacent moors, the basis of the proteolite may be seen gradually becoming more quartzose, and the accessory shorl more abundant, until a granular shorl-rock is produced in the form of nodules and veins. An instance of this transition has been recorded by the Rev. J. J. Conybeare,* who found in a quarry, near

* Trans. Geol. Soc. of London. Vol. IV. p. 401.

St. Agnes, an *elvan* passing (by the addition of tourmaline, and the decrease or loss of all its ingredients except quartz) into a rock resembling that of Roach.

In several species of this rock the colouring or accessory mineral is sometimes uniformly diffused throughout the mass, but more commonly it is partially arranged so as to produce a clouded, striped, or marbled appearance. These varieties form extensive beds in the parish of St. Dennis, in the central district; and also in Madron and Sancreed, in this neighbourhood, near the boundaries of the granite. They become of a light red on decomposition, whereas the hornblende-rocks (with some of which these might be confounded) produce a reddish brown soil.

An extensive *suite* of rocks, in which hornblende constitutes the accessory mineral, generally succeeds the cornubianite and proteolite; it does not, however, exist in actual contact with the central groups of granite, though it often occurs in its vicinity.

The felspar basis of these rocks may be either compact and semi-crystalline, or granular; and both kinds may sometimes be seen passing into each other, as in the case of the two former genera; but more commonly they are entirely distinct, and remote from each other, and pass into very different genera: the one being rich in tin and copper-ores; the other in lead, antimony, and roofing slates.

Although the hornblende-rocks present a greater choice of names than usual, yet it is not easy to select one perfectly applicable to those of Cornwall: but wishing to avoid any unnecessary multiplication

of names, it is proposed, for the present, to adopt that of greenstone or diabase.

The *compact* and *schistose* greenstones repeatedly pass into each other; so that, in traversing them from the granite, they appear to alternate; but this does not hold good to any great extent in the length of their beds; as may be seen on the shores of Mount's Bay, where the massive rocks are insulated in the body of the slate.

On approaching the granite, the greenstone is generally found to be harder, and more siliceous, containing quartz-veins, which sometimes project on the side of the hills in blocks three or four feet in breadth: the hornblende at the same time becomes very much changed in appearance, and cannot at length be recognised as such; and still advancing, shorl succeeds: thus the transition is effected into proteolite, the genus last described; and the dis-

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Gen. 8. GREENSTONE OR DIABASE. A basis of compact or granular felspar, variously combined with hornblende in different proportions; sometimes the one and sometimes the other predominating in the mass. This rock, when decomposed, produces a reddish brown soil.

G. *sienitic*. Crystalline hornblende distinctly arranged in a basis of compact-felspar. *Local*. Davidstow. Hill descending to Pollaphant.

G. *hornblendic*. The hornblende not only intimately blended with the base, but also present in shining laminæ. *Local*. St. Cleer. Tolcarne, near Penzance.

G. *compact*. An uniform mixture of the constituents. This rock is massive and often passes into compact-felspar. *Local*. Trewint. And around Penzance.

G. *lamellar*. Blue, fine-grained, and uniform in texture. Breaks into thick rhomboidal laminæ. *Local*. Rosecradock. St. Cleer. Botallack.

G. *schistose*. A fine-grained blue fissile slate. *Local*. Adjoining all the last.

G. *argillaceous*. A coarse lamellar slate of a pale blue when perfect; but it is generally of a dirty yellow with spots, in consequence of a partial change. Used as a building stone. *Local*. Liskeard.

similarity in the chemical composition of shorl and hornblende is not so great, as to render such an occurrence improbable.

The compact varieties of this genus are the most durable; and protrude from beneath the soil in the form of tors, or are scattered on the surface after the manner of granite. The presence of greenstone, even when concealed from view, is oftentimes declared by the reddish brown colour of the soil, the tint varying in depth according to the proportion of the hornblende in the rock.

The next genus of the porphyritic series, to be noticed, has also a basis of compact-felspar: but the nature of the accessory mineral is rather obscure: it has been called hornblende, but it is probably actynolite, as this substance prevails in a distinct form, both as veins, and as crystalline concretions disseminated throughout the base; or, it may, perhaps, be a peculiar modification, such as often occurs during the passage of one mineral into another.

The most abundant kind of this genus is a hard compact rock, known provincially by the names of *blue stone* or *blue elvan.* It is surrounded by, and passes into, a blue slate, which retains most of the characters of the compact, only it may be divided into thick rhomboidal laminæ: these rocks are of common occurrence on the shores of Mount's Bay. It is worthy of remark, that whilst the massive rock occurs in elevated ridges, and is unchanged, the slaty variety is decayed to a considerable depth, still retaining indeed, its form, but gradually diminishing

in tenacity from the perfect rock to the surface, where it is often in the state of clay: the blue colour, in the same manner, disappears, so that the decomposed rock is ash-white with ochreous stains, or of an uniform pale fawn colour, which distinguishes it from the schistose greenstone. The exemption of the compact rocks from this change may be ascribed to their constituent minerals being more distinct and more crystalline, possessing a greater cohesion of particles, and consequently endowed with a greater power of resisting the chemical action of the elements. Some of the rocks of this genus are very beautiful, having a violet coloured basis: which appears to be occasioned by the compact-felspar passing into massive axinite; for the latter mineral, in crystals, frequently occurs in small irregular veins which traverse this rock, after the manner of calcareous spar in limestone. This axinitic species is sometimes spotted with minute crystalline concretions of actynolite: or the latter mineral is partially combined with the base, producing a blue compound, which forms striped and marbled markings, on a light coloured ground. At first sight, these rocks appear to be well calculated for ornamental purposes; but unfortunately they are traversed by numerous seams or joints, which become discoloured on exposure to the air, in consequence of the presence of iron-pyrites. This mineral, in small amygdaloidal granules, is, in one species, disseminated throughout the base: it has been called by several foreign geologists mandelstein felspar.

Since this genus of rocks abounds in actynolite, it may be called *actynolite-rock*, which is not altogether an innovation, as Dr. Macculloch, following Saussure, has introduced the term actynolite-schist into the list of rocks. It may be objected that, in many of the varieties, actynolite cannot be identified; but the same objection equally applies to the fine-grained greenstones, and many other rocks, into the composition of which hornblende is generally acknowledged to enter, although it is not visible in a distinct form.

Gen. 9. ACTYNOLITE-ROCK. Differs principally from the last, in containing actynolite in the place of hornblende. Its compact-felspar base also exhibits some peculiarities, having sometimes a violet colour, and containing veins and crystals of the same coloured axinite: it, therefore, appears to be a mixture of these minerals; or, perhaps, a compact variety of the latter. These rocks are very beautiful, and abound in Mount's Bay.

A. *compact (blue elvan)*. A very hard and tough rock, of an uniform blue colour; it has a very fine granular texture, sometimes approaching to crystalline. Abounds in minute veins of crystallized actynolite. *Local*. Cuddan Point, the Greeb Rock, Long Rock, Lariggan,—all in Mount's Bay. Gurnard's Head.

A. *axinitic*. Of a lighter colour than the last and commonly mottled; when wet it has a bright violet tint. Abounds in veins of axinite. *Local*. Cuddan Point. Lariggan. Botallack.

A. *amygdaloidal*. Small crystalline concretions of actynolite and of iron-pyrites disseminated throughout the base, which consists almost solely of compact-felspar, of a yellowish white or flesh-coloured. *Local*. As the foregoing.

A. *striped*. The *compact* and the pure base arranged in irregular alternating stripes. *Local*. As the foregoing.

A. *variegated*. Consists of all the preceding species so blended and intermixed in the same mass, as to produce a most complicated but beautiful appearance, oftentimes resembling the mottled skin of a serpent. *Local*. Lariggan.

A. *lamellar*. A very pale blue slate, breaking into flat rhomboidal layers. It is generally disintegrated to a considerable depth. *Local*. Penzance.

A. *schistose*. A very fine-grained and fissile slate: even at the surface this rock cleaves into thin leaves, and if quarried it would, perhaps, improve and be adapted for economical purposes. *Local*. Battery Rock, Penzance.

Each of the preceding genera, but more particularly greenstone, gradually passes into rocks which are for the most part soft and thick lamellar slates of various shades of blue and, sometimes, of green. They contain beds which are compact and earthy, differing only from the slate in which they are imbedded, in wanting the schistose structure: and they abound in metalliferous veins, the matrix of which is composed of quartz and dark green crystalline chlorite; the quartz is sometimes much intermixed with felspar, which decomposing into a white clay, renders the whole of the *lode* friable, and is called by the miner a *priany lode;* Pembroke mine, near St. Austle, affords a good example of this kind of vein.

The rocks of this genus appear to be composed of granular felspar and chlorite, or some such analogous mineral: and they may, therefore, for the present, be called chlorite-rock or chlorolite.

Gen. 10. CHLOROLITE, OR CHLORITE-ROCK. Is a compound of granular compact-felspar and a mineral resembling chlorite. Its species are generally thick lamellar, sometimes schistose, but very rarely massive. Chlorite abounds in quartz-veins containing compact and crystalline chlorite, and which are often very rich in metallic minerals, particularly in copper-ores.

C. *compact.* A very coarsely lamellar rock, rather soft, fine-grained and but very slightly coloured by the accessory mineral. It approaches very near to *compact* eurite, into which it will be probably found to pass. *Local.* In the mining district of St. Austle.

C. *lamellar.* A thick, blue, glossy slate; of a very uniform and smooth texture on the surface of its laminæ, but rather granular and earthy on the cross fracture. *Local.* Hewas. Polgooth. Crinnis. Pembroke.

C. *schistose.* Differs from the last in being more fissile: it appears to contain a larger quantity of the accessory mineral, and becomes very much discoloured on decomposing. *Local.* In the cliffs of St. Austle Bay it is common: and at Duporth it passes into talc-schist.

It has already been stated that the granitic rocks, eurite, felsparite, and shorl-rock, occur in the schists in the vicinity of the junction: the two former are not confined to this locality, but have been detected in each genus, though they assume various appearances in different strata. The most abundant of these is the felspar porphyry (porphyritic felsparite) which occurs in beds of great thickness.

The nature of these granitic rocks has been already discussed: and, since it has been seen that their bases are common to the rocks of the porphyritic series, it is easy to understand the reason of their mutual and intimate connection.

The farther these granitic rocks are removed from the central groups of granite, the more regular they are both in size and direction: they underlie at a very considerable angle, and almost universally to the opposite point of the compass to which the slate dips: running towards the main mass of granite, whereas the latter inclines therefrom.

Dr. Macculloch* observes on this subject, that compact-felspar is the usual basis of those porphyries found associated with the primary rocks;—that there is much difficulty in determining the true nature of these porphyritic masses, as occasionally they seem to cut the strata, while in other places there can be no question that they are parallel to them:—and he concludes, by giving it as his opinion, that they are veins, like trap in the same position.

The Cornish miners appear to entertain a similar

* Trans. of the Geol. Soc. of London, Vol. IV. p. 265. et seq.

opinion concerning these beds of porphyry, as they call them *elvan-courses* or *channels:* this has, I think, arisen on account of the *elvans* differing in structure from the slate. Both of these rocks are divided into thick layers by parallel seams: but between these the former is compact; the latter, schistose. So that the miner, working through a slaty rock, is regardless of the seams, because every random blow of the pick is sure to alight on one; but when he arrives at a massive rock, which presents comparatively few joints, and which extends regularly both to the right and to the left, it is natural for him to call this a *course* or *channel:* it has arrested his progress, and he therefore observes its structure, whilst the more tractable slate is passed by unheeded.

The shores of Mount's Bay afford excellent illustrations of the nature of these porphyritic beds: and those near Penzance, and at Pra Sands, in particular, distinctly shew their transition into the adjoining slate. Like the other massive rocks, these porphyries also alternate in irregular beds: as is well exemplified in the case of the Tavistock Tunnel, recorded by Mr. Taylor;* and also, in the cliffs between St. Agnes and Cligga Point.

Such are the rocks of the porphyritic series: and those of the calcareous series possess similar geological characters; that is, they are capable of being divided into distinct genera, which are composed of massive and slaty rocks, partially alternating and mutually passing into each other.

* Trans. Geol. Soc. of London. Vol. IV. p. 152.

The composition of these rocks is not so easily ascertained as the last; but since analogous hornblende-rocks occur amongst them, it is possible that they may be composed of the same substances: they are modified, however, by the presence of carbonate of lime, which appears to pervade the whole of this series; and as it has been seen that felspar sometimes predominates, in the first series, so as to form beds, so likewise, in the group about to be considered, carbonate of lime is occasionally so accumulated, as to constitute strata of limestone.

I do not know of any spot where these series come into contact with each other: and indeed if a natural section of them were exposed to view, it probably would be no easy matter to draw a line between them, as they are so similar in composition.

As it is difficult to point out the precise line of junction between these series, so is it also to decide to which of these the adjoining genera belong. This is particularly so with the magnesian rocks which will be first described. These rocks occur in several parts of Cornwall, as at Pollaphant, Clicker Tor, Duporth, and the Lizard: it is only at the last mentioned place that they form a large tract of country; affording, perhaps, one of the finest examples of serpentine, and certainly one of the most instructive, on account of the numerous sections exhibited in the sea-cliffs. But although the Lizard is the best place for studying the internal structure of the magnesian rocks, it is inferior to Clicker Tor and Duporth, for disclosing their geological relations.

Approaching the Lizard from Constantine, the magnesian rocks appear to follow strata which are associated with limestone, and which dip at an opposite angle to the former; from which circumstances it is probable, as already stated, that the serpentine is the continuation of a series belonging to a mass of granite, south of the Lizard, and not to that of Constantine. This opinion is also in some measure strengthened by the occurrence, at the Lizard Point, of hornblende-rocks with a bed of talcose slate interposed: thus rendering the position of this serpentine the same as in other parts of Cornwall. And it is farther worthy of remark that the serpentine is preceded by rocks containing calcareous spar in every instance, with the exception of that at Duporth, and is immediately succeeded by rocks containing limestone.

The magnesian rocks of Cornwall may be divided into three genera; into diallage-rock, serpentine, and talc-schist: the last is generally received as a distinct rock, otherwise I should have described it as a schistose species of serpentine.

Sir H. Davy,* and Mr. Majendie,† have observed, that diallage-rock passes into serpentine at Coverack

* Vol. I. p. 34. † Idem. p. 43.

CALCAREOUS SERIES.

The rocks of this series generally contain particles of calcareous spar, or are traversed by veins of the same: and this mineral sometimes so predominates in the mass as to form beds of limestone and calc-schists. This series is not so metalliferous as the porphyritic: copper-ores are not common, but lead, antimony, and manganese, are abundant.

Cove, which confirms the opinion that the latter rock is a compound of the same minerals as the former, differing only in the mode of aggregation. If this conclusion be correct, diallage-rock is analogous to *sienite*, and serpentine to the greenstone of the porphyritic series; indeed, in composition, these rocks appear only to differ in the serpentine containing more magnesia than the greenstone, which explains the intimate connection subsisting between these rocks: and Dr. Macculloch* has recorded a remarkable instance of serpentine passing into trap in a greenstone vein, in Perthshire.

In most of the species of diallage-rock or euphotide, the felspar and diallage are distinctly crystallized; but these minerals are sometimes in such fine granules, that the rock becomes homogeneous.

* Journal of Science and Arts. Vol. X. p. 29.

Gen. 11. EUPHOTIDE OR DIALLAGE-ROCK. Consists of felspar and diallage, both of which are very crystalline, and are generally very distinct, in the form of granules aggregated together, and mutually penetrating each other after the manner of granite: but sometimes these minerals cannot be distinguished, more especially in the schistose species, and in these the felspar base appears to contain more silica resembling the compact variety of this mineral. The felspar in this rock does not appear to be identical with that of granite; it is probable that a portion of magnesia enters into its composition.

* *The component parts crystalline; granitoid.*

E. *granular.* The constituents in grains about the size of a pea. *Local.* St. Keverne. Between the Manacles and Coverack.

E. *coarse-grained.* The granules much larger than those of the last. *Local.* Manacle Point.

E. *fine-grained.* Constituents in very small granules, but still distinct. *Local.* Near Porthoustock. Gwinter. Western side of Kennick Cove. Mullion.

E. *porphyritic.* Crystals of hypersthene imbedded in the foregoing *Local.* Manacle Point.

The hornblende-slate of the Lizard is entirely distinct from that of the other parts of Cornwall; and, therefore, ought to be separated therefrom. In the foregoing pages the transition of this slate into euphotide and serpentine has been repeatedly noticed: but it is more closely allied to the former, as is shewn by its great hardness, and by its resplendent lustre; and it is, therefore, proposed to distinguish it by the name of schistose euphotide.

This schist appears sometimes to be imbedded both in the euphotide, and in the serpentine; and at other times, the latter rock seems to be subordinate to the schist: but the fact is, that all of these, (like the massive and slaty species of greenstone) although they alternate on a given line, yet they do not long continue parallel, nor do they preserve a continuous course for any considerable distance: but they mutually *abut* against each other, sometimes the one and sometimes the other prevailing.

Serpentine exhibits a great many varieties; some of which are very hard, whilst others are so soft as to yield to the nail: this difference appears to depend

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** *The component parts not distinct.*

E. *compact.* A massive rock, in which the constituents can no longer be distinguished. *Local.* Porthoustock. Manacle. Bolerium, near Mullion.

E. *lamellar.* Similar on the cross fracture to the compact, but interlaminated with scales of diallage, which makes the surface of this rock sparkling and glossy. *Local.* Porthoustock. Cadgwith. Landewednack. Mullion. Lower Pradanack.

E. *schistose.* Very fine-grained homogeneous and fissile. *Local.* Landewednack. Housall Cove. Bolerium.

E. *striped.* The preceding with alternating laminæ of the simple basis, which is generally quartzose. *Local.* Cadgwith. Landewednack.

on the felspar base which undergoes several modifications between a crystalline, compact, and granular state, as seen in the precious serpentines, in the indurated steatites, and in the common and ollareous serpentines. In the same manner, as the rocks of the porphyritic series assume various properties, according to the condition of the compact-felspar base: with this difference, however, that in the latter the proportion of the silica appears to modify the compound, whereas in the former, it is to be attributed to magnesia. The accessory mineral (diallage)

Gen. 12. SERPENTINE. Has a basis of magnesian compact-felspar, (that is, a combination of the felspar of the euphotide with variable proportions of magnesia, and perhaps of silica) which basis is intimately united with various kinds of diallage, whence it derives its colour; and it also contains this accessory mineral, in crystalline scales, and other distinct forms. Serpentine is traversed and much intersected by irregular veins and layers of different kinds of steatite, which probably differ very little in composition from the magnesian felspar base.

* *With a granular basis.*

S. *granular*. Colour various, but generally dark olive green: very fine-grained and rather hard; and of an uniform composition. *Local*. Dranna. Clicker Tor. Duporth. Chynhals Point. Trelowarren-gate.

S. *lamellar*. Composition similar to the last, with the addition of diallage so arranged as to make the rock schistose. *Local*. Dranna. Between Ruan Minor and Cadgwith. Vellan Point.

S. *striped*. Differs from the last in alternating laminæ, being of divers colours. *Local*. Dranna.

S. *diallargic*. A base of the granular *species*, throughout which scales of diallage are interspersed: these vary in colour from red to green; and, in the quantity present in the mass. *Local*. Coverack. Lizard. Kinance. Kennick. Higher Pradanack.

S. *ollareous*. The basis granular and soft, resembling potstone, with disseminated scales of diallage. Quarried as a building stone. *Local*. Pollaphant.

S. *spotted*. A compact and tough rock, the basis of which is of a dark grey, thickly mottled with white and angular portions of a mineral like steatite. *Local*. Duporth, near Charlestown.

also imparts characters to the serpentine according as it is intimately combined with the base, or is disposed in distinct forms: this mineral also experiences transitions, passing into talc, asbestus, tremolite, and, perhaps, into intermediate substances.

Both of the component minerals, in all their modifications, frequently occur in irregular strings, veins, and layers, which traverse the serpentine rocks in various directions.

Talc-schist is intimately connected with euphotide and serpentine by the change of diallage into talc: it is too well known to need a particular description; but, it may be observed, that the Cornish variety is

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** *With a compact basis, translucent on the edges.*

S. *precious.* Of an uniform smooth texture: it is often of a dark olive by reflected, and of a light rich green by transmitted, light: sometimes of a fine dark brown when viewed through its edges. *Local.* Kinance. Gue Graze.

S. *compact.* A very dark coloured rock, but of a pale green in thin pieces. It is rather fine-grained on the cross fracture. *Local.* Cagar, near Ruan Minor.

S. *violet.* A compact-felspar base of a violet colour, with imbedded scales of diallage. *Local.* Gwinter, near Kennick Cove. Coverack.

S. *steatitic.* A basis of indurated steatite, with or without arborescent and other markings. *Local.* Black Head. Gue Graze.

Gen. 13. TALC-SCHIST. A basis of granular felspar, intermixed with, and laminated by, talc, which can only be seen in distinct scales in the veins traversing this rock. It is a glossy slate, having the peculiar saponaceous feel of magnesian minerals.

T. *foliated.* A dark bluish grey when perfect, becoming of an ochreous yellow when changed: breaks into thin irregular folia, which are very glossy. It abounds in nodules and short veins of quartz and calc-spar, containing scales of talc. *Local.* Under the Light-houses at the Lizard.

T. *lamellar.* Divides into thin laminæ, the cross fracture of which is granular: it is soft and steatitic. *Local.* The north side of the Dranna serpentine.

T. *crenulated.* Like the last, but more glossy and unctuous; the laminæ are arranged in angular plaits. *Local.* Duporth Cove.

T. *schistose.* A very fissile glossy slate. *Local.* Trenalt, near Pollaphant. Bossinney Cove.

a compound of compact-felspar and talc, bearing the same relation to the true talc-schist, as the slate of St. Breward does to mica-slate.

Connected with the *ollareous* serpentine of Pollaphant, and immediately succeeding it, are strata of calc-schist, which have a very glossy appearance, derived probably from a mixture of talc, which is present in the quartz-veins, and in the bed of limestone which occurs in this schist. The limestone, besides being much intermixed with talc, contains nodules and large masses of hornstone.

It is proposed to form a new genus of these strata, under the name of talcocalcite. I observed a schistose variety of this rock at Cotele, on the Tamar, near Calstock: but I have not detected it in any other part of Cornwall.

It has been stated, that the strata immediately following the magnesian rocks, contain beds of limestone; as may be seen in the sections from Clicker Tor to the Rame, and from Grampound to Veryan.

Gen. 14. TALCOCALCITE. Is a compound of the same minerals as talc-schist and of calcareous spar: its constituents are variously aggregated; sometimes the one, and sometimes the other predominating in the mass; but all its species effervesce more or less in dilute muriatic acid.

T. *compact*. A light coloured limestone with a silky lustre. It is much intersected with veins of calc-spar. *Local*. Trenalt, near Pollaphant.

T. *schistose*. Has a fine texture with shining lustre, and is very fissile. *Local*. Trenalt.

T. *lamellar*. It is of a dove colour and very glossy: breaks into rhomboidal slabs. *Local*. Cotele.

T. *siliceous*. Similar to the compact, but contains more silica, which sometimes so much prevails as to produce hornstone and other siliceous minerals. *Local*. Trenalt.

This limestone *suite* of rocks forms a considerable extent of country on the southern part of Cornwall, which being fertile does not afford many opportunities for examination. When the magnesian rocks are wanting, the limestone *suite* is, like the former, immediately preceded by hornblende-rocks, containing calcareous spar: and this mineral gradually increases, as you recede from the granite, until it so far prevails as to form limestone, which, however, always partakes of the nature of the hornblende-rock; i. e. it is composed of carbonate of lime, compact-felspar and hornblende, in various proportions. Such is the simplest form of transition in this *suite;* but it is generally more complicated: the quartz sometimes prevails in the compact-felspar base, giving rise to various kinds of massive and granular quartz-rocks; and the hornblende, in like manner, produces rocks which are not easily distinguished from the greenstone of the porphyritic series, just as the latter contains beds which are common to the granitic groups. And again, each of these massive rocks gradually passes into slate, which always partakes somewhat of the characters of the respective rocks with which it is associated. Thus, though it is difficult to describe all the varieties of this *suite,* and more particularly so when they are only examined in one part of the county, yet it is hoped that, after these general observations, their nature will be easily understood. I shall, therefore, only make a few remarks on some of these rocks, concerning which there has been a difference of opinion.

The compact rock at Grampound, and elsewhere, containing grains and nodules of quartz, has been pronounced a true greywacké: and the crystalline granular rock at Mawnan, which owes its peculiar appearance to the dissemination of small and irregular portions of carbonate of lime, has also been referred to the same formation. But on the view of the subject here advanced, they are considered as original or primary rocks, each having one of its constituents separately aggregated into a distinct mineral, in the same manner as the granules and crystals in a basis of felspar-porphyry.

At the commencement of this *suite*, preceding the beds of limestone at Tregoney and St. Anthony, in the central district, on the banks of Helford Harbour and elsewhere, a coarse lamellar rock is of frequent occurrence; when unchanged it is blue, granular in its texture, and contains numerous minute spangles of mica, to which it appears to owe its lamellar structure; but it is generally disintegrated to a great extent, when it becomes of a yellowish brown colour, and arenaceous in its texture; and has been mistaken for an argillaceous sandstone. This rock is always associated, and alternates, with a blue glossy and iridescent slate, which has a very fine texture, and is fissile, but on its cross fracture is splintery.

This limestone *suite* likewise occurs on the north coast, between Wadebridge and Padstow. Some of its varieties, however, differ from those on the south coast, but not materially: that at Port Isaac and Endellion may be particularly noticed; it contains

amygdaloidal nodules of calc-spar, which are removed during *weathering*, leaving a vesicular and earthy compact-felspar, stained with oxide of iron, derived from the decomposition of the hornblende.

Such are the principal rocks connected with the black limestones of Cornwall: and I think that they may all be divided into three genera; comprising 1st. the hornblende rocks,—2nd. the limestones and calcareous schists,—and 3rd. the lamellar micaceous rocks, and the slates associated therewith, which form the principal part of this *suite* of rocks, and in which the hornblende and limestone rocks are generally imbedded.

These hornblende-rocks, as they differ from those of the porphyritic series, ought to be distinguished from the genus greenstone; and until a better name be proposed, it may be called *corneanite*.*

* De la Beche has applied the term *cornean* to designate a variety of trappean rocks in Pembrokeshire, "which," he says, "may be divided into felspathic, quartzose, and hornblendic, as those minerals appear to prevail in the mass."—Geological Manual, p. 470. Perhaps the rocks here described under the name of *cornean*, are equivalent to the greenstone of the porphyritic series: if so, this term might be adopted in the place of greenstone; and some other might be invented for the hornblende-rocks of the calcareous series.

Gen. 15. CORNEANITE. This rock is very similar to the greenstone of the porphyritic series; so much so, that it sometimes cannot be distinguished therefrom, in hand-specimens; perhaps analysis, and a more minute examination, may detect characters as distinct as those which separate them on a large scale. It has a basis of various kinds of compact-felspar, combined with hornblende, which is commonly in a less proportion than in greenstone. It sometimes contains particles, granules, and minute veins of calc-spar, by means of which it gradually passes into the limestone of the next genus: it also occasionally abounds in granules and nodules of quartz; and this

The black limestone of Veryan has been analyzed by the Rev. Mr. Gregor, who found a hundred parts of a *good* specimen to yield $89\frac{1}{8}$ carbonate of lime, 10 silex mixed with manganese, and $\frac{7}{8}$ oxide of iron.* This must have been a selected sample, such as is only to be found in nodules and thin layers; for an average specimen of the whole stratum of this rock (which is often more than fifty feet in width) would,

* Vol. I. p. 108.—The Rev. S. Trist, on the Veryan limestone.

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mineral often so predominates in the base, that it becomes almost entirely siliceous. Corneanite sometimes contains veins of antimony and lead; but it more abounds in manganese.

C. *compact*. An uniform mixture of the constituents forming a hard and massive rock. *Local*. Egloskerry. Tresmear. Otterham. Rediver Mill. Wadebridge. Fowey. Portmellion. Dodman. Porthscatho. Mylor. Pendennis.

C. *mottled*. Resembles the compact, but some portions of the base being free from the colouring mineral, give it a mottled appearance. It abounds in cubes of iron-pyrites. *Local*. Tregamenna and Penare Point, near Veryan.

C. *granular*. Coarse-grained crystalline and hard, spotted with white carbonate of lime. *Local*. Mawnan.

C. *calcareous*. The compact abounding in crystalline scales of calc-spar. *Local*. Pengover. St. Ive.

C. *amygdaloidal*. Round granules of calc-spar and minute crystals of hornblende disseminated through a light coloured compact basis. When decomposed this rock becomes vesicular, earthy, and of an ochreous colour. *Local*. Port Isaac. Endellion. Hell Bay, Padstow Harbour.

C. *siliceous*. Very compact and hard: fine-grained and of an uniform texture. It abounds in small irregular veins of quartz and of calc-spar. *Local*. Between Wadebridge and Camelford. Tregoose, near Grampound. Porthscatho, near Gerrans.

C. *quartziferous*. A basis of the *compact*, containing rounded grains and nodules of siliceous minerals. *Local*. Grampound. Near Tinker's Lake, on the road from Liskeard to Tor Point.

C. *quartzose*. Consists almost entirely of quartz intimately blended with a minute portion of the compact, which also occurs in irregular veins and patches. *Local*. Carne and Crowan, near Veryan.

C. *lamellar*. Dark blue and glossy: breaks into thick rhomboidal laminæ. *Local*. Near Trerule. Tor Point-road.

C. *schistose*. Blue without much lustre: rather soft, but very fissile. *Local*. Penquean on the Camel. Tinker's Lake, on the road from Liskeard to Tor Pt.

I think, afford other ingredients besides those mentioned, and a much smaller proportion of carbonate of lime. In general this rock is so different from all the true limestones and marbles, and is of such frequent and extensive occurrence in Cornwall, that it deserves a distinct appellation, and I beg to propose that of *corneocalcite* which denotes its intimate connection with the preceding genus: under the head of corneocalcite will be included not only the compact calcareous rocks, but also the several calc-schists into which they pass.

The third and last part of this *suite*, comprising the lamellar and schistose rocks, may be called *phyllade:* those species which are most remote from the granite, might be termed *clay-slate;* but this name

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Gen. 16. CORNEOCALCITE. Is an intimate combination of carbonate of lime, with the constituents of corneanite: and the former sometimes so predominates in the mass, as to form a limestone. It effervesces in dilute muriatic acid.

C. *compact (black lime).* A hard massive compound in which calcareous earth prevails: it is much intersected by veins of calc-spar. It burns well, producing a lime like that of Aberthaw. *Local.* Rock Ferry, Padstow. Dinham on the Camel. Yeolm Bridge. Permiscen Bay. St. Germans. Veryan.

C. *resplendent.* A dark blue limestone, with numerous minute white facets of calc-spar disseminated throughout. It is compact, hard, and very tough. It is burnt into lime. *Local.* Trerule Foot, Tor Point-road.

C. *hornblendic.* Differs from the resplendent in containing distinct particles of a black mineral, like hornblende. *Local.* On the shore under Gwendra, near Veryan.

C. *lamellar.* Breaks into thick rhomboidal plates: lime is not the predominant constituent. *Local.* Rock Ferry, Padstow. Permiscen.

C. *schistose.* Passes into *lamellar corneanite,* which it much resembles, differing only in containing carbonate of lime. *Local.* Trerule Foot. St. Germans. Porthalla. Near Buckapit Bridge.

C. *striped.* Like the schistose, only variegated with brown stripes. *Local.* Yeolm Bridge. Permiscen Bay.

has been applied so indiscriminately to such dissimilar rocks, that its application, in this case, might create confusion.

In the northern part of Cornwall and of Devon, there is a considerable tract of rocks which are very nearly allied to those just described, under the name of corneanite. These rocks consist in a great measure of very thick beds, which are coarsely lamellar, and even compact and jointed like the felspar rocks; indeed, they seem to be principally composed of felspar, even the most compact and siliceous becoming *weathered* on exposure to the air: and all the varieties arise from the proportion of silica that enters into the mass. At Tresmear, and other places inland, the rock is a kind of granular felspar; at Poundstock and Whitestone it is more siliceous and arenaceous; the latter variety generally prevails in elevated situations; for the same reason, as repeat-

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Gen. 17. PHYLLADE. This rock differs in a great measure from corneanite, in having a granular, instead of a compact basis: and it always contains minute spangles like scales of mica, although these are sometimes but very sparingly disseminated throughout the mass.

P. *lamellar*. It is blue; compact and granular between the laminæ, the surfaces of which are covered with minute spangles of mica. It readily decomposes, and becomes yellowish and arenaceous. *Local*. Tregoney. Cargurrel, near Gerrans. St. Anthony, in Powder. Portreath. Mawnan. Helford.

P. *quartzose*. Differs from the lamellar in silica predominating in the base. *Local*. Dedman. Resemullion Head. Lantivit Bay. Polperro. Looe.

P. *schistose*. A fine blue slate, often tarnished on the surface with iridescent colours. It is very fissile; hard and splintery on the cross fracture. *Local*. Near Tregoney Bridge. St. Anthony, in Powder. Portreath. Mawnan.

P. *striated*. Irregularly fissile, surface striated, in other respects like the lamellar. *Local*. Cargreen Point, on the Tamar. Near Hay, between Tregoney and Veryan.

edly observed, that the more indestructible rocks have been less acted on and excavated, than those that are prone to disintegration. On the sea-shore they are quartzose; and thence the immense and terrific reefs that prevail on this part of the coast: they alternate with dark blue and fine-grained slates, which are hard, and have a conchoidal fracture; but are subject to disintegration from the iron-pyrites that is disseminated throughout them. This slate often exhibits a peculiar structure, containing flat ovoidal concretions, which are more durable than the interstices: so that during its decay this rock furnishes ready formed flattened pebbles, which, when met with inland, as at Tresparrett Downs, would be pronounced by most persons to have been formed by attrition on the sea-shore. I have only seen one bed of limestone in this *suite* of rocks, near a slate quarry on the northern side of Werrington; but I understand that this rock also occurs near Stratton, Kilkhamton, and elsewhere.

In consequence of the Rev. J. J. Conybeare's description of these rocks, in his account of Clovelly, I have placed them under a distinct genus: my opportunities for studying them were not very favourable, but I entertain doubts of the propriety of separating them from the genus corneanite. The principal variety of these rocks, observes this geologist, "is known throughout Devonshire by the appellation of *dunstone:* it answers pretty accurately to the description usually given of that species of greywacké, in which the fragments supposed to be

cemented together by the intervention of a paste resembling the matter of clay-slate, are too small to be discerned even by the aid of a considerable magnifier."* "It alternates with a fine-grained slate in distinct and well defined strata, sometimes appearing to graduate into each other, and the compact species assuming the external configuration of greenstone and serpentine." "It is destitute of metallic veins. It alternates with transition limestone, and where it does so, occasionally contains organic remains: it also alternates, in one instance at least, with large beds of a species of culm. Its veins contain few or no extraneous substances, besides common quartz and, though less frequently, calcareous spar."

The limestone *suite*, near the mouth of Padstow Harbour, is succeeded by extensive beds of red and

* Trans. Geol. Soc. of London. Vol. II. p. 496. et seq.

Gen. 18. DUNSTONE. This rock is principally composed of compact-felspar in which silica generally predominates: the nature of its colouring mineral is not evident. It abounds in quartz-veins, iron-pyrites, and manganese. It is traversed by beds of *black* limestone: and is said to contain a variety of culm. It appears to be nearly allied to, if it be not the same as, the genus corneanite.

D. *compact*. Granular and felspathic, producing an arenaceous soil on decomposition. *Local*. Tamerton. Whitestone. Kilkhampton. Moorwinstow. Poundstock. St. Gennys. Jacobstow.

D. *quartzose*. The basis very siliceous, approaching near to quartz. *Local*. Crackington Cove. Widemouth Bay. Stanbury Creek.

D. *schistose*. Dark blue, very fine-grained, fissile in the direction of the layers, but very splintery on the cross fracture. Contains disseminated particles of iron-pyrites, which cause it to decay. *Local*. Crackington Cove, near St. Gennys. Stanbury Creek, Moorwinstow. Boyton.

D. *nodular*. Similar to the schistose, containing flat ovoidal concretions arranged parallel with the laminæ of the rock. *Local*. Crackington Cove. Widemouth Bay.

greenish slates, which appear to be a variety of honestone. These slates are associated with a massive crystalline rock, forming the headlands: it is a kind of sienite, consisting of small prismatic crystals of glassy felspar, intermixed with a dark coloured mineral, probably hornblende; it is very hard and tough, gradually passing into the slates just mentioned, which accounts for their peculiar properties.

When I examined these rocks, I saw no reason to suppose that they were not immediately connected with, and in continuation of, the limestone *suite;* and I have, therefore, described them accordingly: but probably they may be found on a stricter examination to belong, like the Lizard serpentine, to another series of rocks connected with a mass of granite parallel with the central patch of the district. Be this as it may, these rocks are quite distinct from any others; and, therefore, on the plan laid down, require a peculiar appellation: this might be derived from the slate, and called *novaculite;* but the more correct way would be to invent a new name for the

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Gen. 19. NOVACULITE. A compound of a hard crystalline felspar, and a mineral, like hornblende, in fine crystalline grains.

N. *sienitic.* In this the felspar is of the glassy variety in small prismatic crystals; and the accessory mineral is not abundant, and occurs between the prisms in minute grains. *Local.* Stepper and Pentire Points.

N. *granular (Cataclew stone).* Is a fine-grained mixture of its constituents. *Local.* Cataclew. Gunver Head. Stepper Point.

N. *compact.* Differs from the first in the granules of its respective constituents not being distinct. *Local.* Cataclew.

N. *schistose (honestone).* Is fissile, which distinguishes it from the former which is massive. It is very fine-grained, and of an uniform texture: in the cross fracture it is splintery. Sometimes red or greenish, and at other times both colours, in stripes, occur in the same stone. *Local.* On either side of Padstow Harbour.

massive rock: but, perhaps, for the present it is best to adopt a term that has already been in use, but not so generally as to lead to any confusion by its employment in a different and restricted sense.

A very interesting *suite* of rocks remains to be described: it occurs only in the Hundred of Lesnewth, in the eastern district: it appears to lie in a curved line parallel with the northern side of the central granitic group to which it approaches, at Brey, within the distance of three miles.

The members of this *suite* are, for the most part, varieties of slate, which are seldom exposed to view; it, however, contains a few massive rocks, one of which is very crystalline, and protrudes above the surface at several places: it is a compound of a kind of fibrous hornblende and calcareous spar, intermixed in different proportions. Attempts have been made to burn this rock into lime, but without success, except when the charge consisted almost entirely of the veins of calc-spar which traverse this rock. It cannot, therefore, be correctly called a limestone: it is a rock *sui generis*, to which a distinct name ought to be applied; perhaps either *amphibocalcite*, denoting its composition, or Lesnewthite, shewing its

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Gen. 20. AMPHIBOCALCITE. A crystalline compound of a green laminated mineral, like hornblende, and calcareous spar.

A. *compact*. The constituents aggregated into a granular mass. *Local*. Grylls. Trevine, near Davidstow.

A. *lamellar*. Similar to the last, but the hornblende more continuous, imparting a lamellar structure. *Local*. Grylls.

A. *schistose*. Fine grained and its constituents intimately blended: it is green, glossy, foliated, and very tough. *Local*. Mid-way between Nathan's Kieve and Trethevy. Trevine. Tremail.

locality, might be adopted. This rock and the slates with which it is associated, immediately follow the hornblende-rocks (the *sienitic* greenstones) of Davidstow; and they appear to have the same composition as the latter, with the addition of carbonate of lime, as some of their thick lamellar slates seem to consist of hornblende and a kind of granular felspar.

Another very interesting member of this *suite* remains to be noticed, and it is an important one, as furnishing the best roofing slate in this country, and probably not inferior in durability and the thinness of its laminæ, to any in the world. It is quarried in two places, at Delabole and Trewarnet, both near Tintagel, and is commonly known by the name of Delabole slate. This rock is generally called clay-slate, but it is distinct from any other kind of slate; and on this account it will be described under a separate head. One fact may, however, be first noticed, as it shews that this slate, although not seen in contact with the amphibocalcite, forms part of the same *suite*. It is this;—in the slate of Delabole some portions are not fissile, but occur amongst the good slate in the form of irregular bunches, which when broken exhibit a coarse lamellar structure; and contiguous to these parts occurs a crystalline foliated substance, precisely the same, in composition, as the amphibocalcite: the quartz-veins also, which traverse this slate, contain crystalline felspar, hornblende, and calc-spar. Hence it may be concluded that the Delabole slate is composed of these minerals, or of the elements of which these are com-

posed: and it is proposed to distinguish this slate by the name of *delabole* or *delabolite*, which genus will also include several kinds of coarser slates, and crystalline laminated rocks, with which the roofing slate is intimately connected.

In the various kinds of delabolite will be found those peculiar concretions, which consist of radiated striæ, resembling the impressions of shells, and which have been pronounced by several geologists to be derived from organic remains. The Rev. J. J. Conybeare,* in his notice on this subject merely refers to the "specimen of slate, bearing the impressions of several shells," without attempting even to suggest to what genera they belong; which is rather surprising, as he might have obtained the

* Trans. of the Geol. Soc. of London. Vol. IV. p. 424.

Gen. 21. DELABOLE OR DELABOLITE. Appears to be a compound of the same minerals as the last, with the addition of compact-felspar, which is the predominant constituent. It does not effervesce in acids, except when it contains small irregular veins of amphibocalcite.

D. *tabular*. Fine-grained, and hard: breaks into very large and thick slabs. *Local*. Trevalga.

D. *lamellar*. The constituents arranged in small but distinct granules. *Local*. Nathan's Kieve. Lesnewth.

D. *schistose*. A very smooth and fissile slate, but not continuous in leaves sufficiently large to form a roofing slate. *Local*. Penpethy.

D. *tegular (Delabole slate)*. A very fine-grained and hard rock, cleaves into very thin leaves, which are translucent on the edges; whence the grey mottled appearance of its surface, being covered with thin minute scales, as if the slate had not separated by natural joints, but had been cloven through its substance, like wood. It is traversed by veins of quartz, containing beautiful and regular crystals of this mineral. *Local*. Delabole. Trewarnet.

D. *pyritous (cliff slate)*. More fissile than the schistose: its surface is granular from minute particles of hornblende, and it contains particles of iron-pyrites, which cause it to *weather*. *Local*. Wildtown.

opinions of the most experienced conchologists: and I am inclined to suspect, though perhaps unjustly, that the plate which accompanies his notice is not a little indebted to the pencil of the artist; for I have seen several specimens, but not one in which the markings have such a near resemblance to shells. And De la Beche,* in his description of the lowest fossiliferous slates, observes that "the organic remains obtained both at Tintagel and on the summit of Snowdon, are far from being well preserved. Those of the *latter* are most determinable, and are found chiefly to consist of shells, and among these shells some *appear referable to the genus Producta.*"

This difficulty of ascertaining the precise nature of these shells, confirms me in the opinion that these impressions are not to be attributed to organic bodies, but to a peculiar arrangement of the component parts of the rock. Many of the coarser and more irregular of these radiated concretions are very crystalline; and will often effervesce strongly in acid: this property may, by some, be thought to confirm their organic origin; but it ought rather to be attributed to calcareous spar, which forms (as has been just shewn) one of the constituent parts of this rock, and which, by the aid of a magnifier, may sometimes be seen in these concretions.

This question is very important, and one which geologists should endeavour to decide; for these slates appear to be connected with the granite by a continuous chain of gradual transitions.

* Geological Manual. p. 457.

Intimately connected with, and succeeding the rocks just described, are the slates around Boscastle. The most characteristic of these are dark blue, almost black, do not alter in the streak, and are uniformly combined with a carbonaceous substance, which also occurs in veins and layers, and which appears to be a variety of anthracite. These rocks also abound in iron-pyrites: and also contain immense layers and nodules of quartz, with which the rock itself is sometimes intimately blended. They are generally much curved and contorted; and the quartz veins often partake of the most complicated inflections.

The varieties of these rocks are arranged below, under the head of *shale*.

Gen. 22. SHALE. This rock in its geological position succeeds the delabole: it is in some respects very like the dunstone; its rocks being sometimes hard and very compact, and abounding in iron-pyrites, but it differs therefrom in generally containing a carbonaceous mineral, as one of its component parts.

S. *pyritous*. A very dark blue schist, glossy on the surface of its laminæ, but earthy on the cross fracture: breaks into thick rhomboidal layers, between which it is fissile; and all the joints of which are coated with iron-pyrites, which is also disseminated throughout the slate in small granular concretions. It does not alter its colour in the streak. *Local*. Tresuck and Valency Hill, near Boscastle.

S. *striated*. Similar to the last, but the surface of its laminæ covered with elevated striæ. *Local*. Battens. St. Juliot.

S. *schistose*. Like the first, but finer grained and very fissile. *Local*. Boscastle. Forrabury.

S. *compact*. The preceding abound in large veins or rather layers of quartz; next which they are hard and less schistose, consisting apparently of the same substance as the slate, intimately combined with the quartz: this rock also forms distinct beds lying parallel with the layers of the slate. *Local*. Valency Hill, Bunwy Creek, Fire Beacon, Pelly and Forrabury Points, near Boscastle.

S. *carbonaceous*. It is common throughout Cornwall to find each of the constituents of a rock separated into layers or beds; and so it occurs with the carbonaceous mineral contained in this genus, which forms a layer approaching, in its properties, to plumbago. *Local*. Willapark cliff, near Forrabury.

Almost every genus both of the porphyritic and the calcareous series of the schistose group, contains some rocks, in which silica so abounds, that they might be called quartz-rock: but I have preferred placing them amongst the species; because the quartz is always more or less combined with the colouring or accessory minerals of the adjacent rocks, and because it is only a variety of the compact-felspar base, which exhibits every gradation between crystalline felspar and quartz, according as one or other of these minerals predominates in the mass.

Some of these quartzose species occupy very extended tracts of country, the boundaries of which are distinctly marked by barren downs. Those which are situated near the granite have been very productive in tin and copper-ores; so that their mineral contents compensate for the poverty of their surface: and many landed proprietors, who have at first despised these bleak and sterile wastes, would when better informed, willingly exchange their pastures and woods, for an equal number of these acres. Thus the bounties of Providence are wisely distributed, so as to render every part of the globe subservient to the wants and comforts of man: and in confirmation of which it may also be observed, that these quartzose rocks, in consequence perhaps of their not being liable to disintegration, are left standing in the form of hills and elevated downs, thus affording, though they themselves are unfavourable to vegetation, shelter to the productive valleys, from the storms that sweep from the ocean over our

narrow peninsula; they also serve to irrigate the valleys with the condensed fogs and rains, which their hard and compact substance will not absorb.

Such are the various genera of the Ocrynian Formation; and imperfect as their classification must necessarily be, as a first attempt, yet it will, I trust, prove that Cornwall affords a greater variety of rocks than has generally been supposed.

ON THE STRUCTURE OF THE GRANITE AND SCHISTOSE ROCKS, INCLUDING SOME REMARKS ON THE ORIGIN OF THE CORNISH VALLEYS.

Having described the composition and geological relations of the Cornish rocks, it is now proposed to offer a few remarks on their structure: this subject has indeed, in part been unavoidably anticipated in the preceding pages, but it is desirable to bring together all the facts, into one point of view.

Granite, as is well known, separates on *weathering*, into quadrangular blocks; and, in cliffs, and in the upper part of quarries, it is found to be traversed by numerous *joints* or *seams* which intersect each other at right angles, dividing the rock into square masses: these *seams* become gradually less distinct, the deeper the granite is penetrated into; but still the same structure exists, as this rock readily cleaves into blocks, having the same regular forms. When the *seams* are well developed by a partial decay, some will be found to be parallel, larger, and more distinct than the others: and these divide the granitic rocks

into layers, which are sometimes perpendicular, but more frequently are inclined at considerable angles, varying from 45°, to 80°. The lesser angles belong more generally to eurite, felsparite, and shorl-rock; so that, these rocks have the appearance of traversing the true granite. In the case of the porphyritic felsparite, (felspar-porphyry) the layers are internally divided into rhomboidal masses. These facts appear to indicate that the concretionary forms of granitic rocks depend on their mineral composition.

The rocks of the schistose group have a similar structure, the compact varieties in particular, do not differ in this respect from eurite and felsparite; but the layers (strata) of the slates are inclined at a less angle, and the various rhomboidal masses of which these layers are composed, have an internal schistose structure, which is generally parallel with the surface of the layers, but in some few instances is nearly perpendicular thereto: thus the structure of the compact and schistose rocks principally differs in the concretionary masses of the former, being uniform and massive throughout, whilst those of the latter are more or less fissile.

As regards granite and other compact (unstratified) rocks, the nature of these *seams*, dividing the mass into regular blocks, appears to be generally acknowledged; "it exhibits" says Mr. Weaver*, in his description of the East of Ireland, "the dissection of distinct concretions, being separated and becoming obvious by the influence of the atmosphere." And

* Trans. Geol. Soc. of London. Vol. V. p. 139.

if this be admitted, then must also the layers of the primary schists, be attributed to the same concretionary structure; the result of a peculiar crystalline arrangement of the constituents of these rocks, which assume various concretionary forms, according to their nature and to the proportions in which these are united: and which concretions, according to their form, produce, by their aggregation, layers inclined at different angles.

I am aware that the opinion that refers the structure even of the *unstratified* rocks to a species of crystallization, as advocated by Professor Jameson and others, has called forth severe animadversions: all hypotheses, however, and even the most perfect theories, are only of transient duration; but even the most ephemeral are generally deserving of respect, as they lead to controversy, and often elicit truth. What I mean to express by the structure of primary rocks being the result of a peculiar crystalline arrangement, is that the constituents of these rocks (whether simple or compound minerals) have been aggregated together by the power of cohesion, so as to produce masses or concretions having determinate forms: which process is certainly a kind of crystallization, even though it should be exerted on substances which had been previously or contemporaneously crystallized. That the forms of the individual blocks or masses of rocks are very diversified, and oftentimes not easily described, is not to be wondered at, when their ever varying and complicated composition is taken into account: for even in

the case of the comparatively simple substance, calcareous spar, how numerous and intricate are the varieties of its crystals.

On this view of the subject, granite is stratified, as well as the shistose rocks: and if so, the division of the primary rocks into stratified and unstratified is incorrect.

Mr. Greenough* observed many years ago that no terms were more vaguely and indefinitely used than those of stratum and stratification: and since that time they certainly have not been rendered more intelligible. The term stratum, says De la Beche,† should, perhaps, only be applied to a bed of rock, the upper and under surfaces of which are parallel planes, but it is also employed to designate beds, the upper and under surfaces of which are irregular.

According to this definition, granite which occurs in such beds, is a stratified rock; but this term is now used in a hypothetical acceptation, and implies that all the schistose rocks have been formed by a mechanical or chemical deposition from water.

Perhaps these terms, stratified and unstratified, might be advantageously restricted to the derivative rocks: the former, denoting those rocks which are, at present, in a horizontal position; or which, on account of their regular and extensive parallism, appear to have been so at the time of their production; the latter, those massive and unconformable rocks by which the former are frequently intersected.

The layers of the schistose rocks of Cornwall are

* First principles of Geology. p. 90. † Geological Manual. p. 507.

inclined at a lower angle than those of granite, varying from 15°. to 40°. They, however, seldom maintain their parallism or dip for a considerable distance, being more or less curved; so that their dip frequently corresponds with the sides of the hills, on the top of which they are often found to be horizontal: and thus, on approaching the sea-shore, the land rises towards the cliff, if the latter has been produced by a section in the descending curve of the layers, and *vice versâ* the land slopes down to the sea. This statement appears to be at variance with the general opinion, that the slate inclines from the granite on every side of its insulated groups: and so it is, when the layers of the slate are examined in detail; but, viewing them on the large scale, the general curvature of the layers of these rocks will be found to have a constant tendency to such a direction, though some of the smaller intervening curves may not accord therewith.

This curvature at right angles with the granite, is always accompanied by another parallel thereto, producing an undulation, like the waves of the sea. These secondary curves also exhibit a general tendency to decline towards certain points: in the principal north and south curves, this is from the east towards the west; and in the east and west ones, it is from the north towards the south:—thus corresponding with the surface of the county which exhibits a declination from Launceston to the Land's End; and, from the north to the south coast.

Thus we learn that the form of the Cornish hills

and valleys have originated in a great measure from the curved structure of the rocks. On this subject Mr. Hawkins* has also observed, that he has always been of opinion, "that the very uneven surface of some portion of the slate district in Cornwall and Devon, was connected in no small degree with its interior structure; having constantly noticed that those parts of the country, which were most uneven, were those of which the slate beds were the most capricious, both in their direction and inclination." In no part of Cornwall is this connection better illustrated than in Minster, St. Gennys, and the neighbouring parishes: where the country consists of a succession of rounded and abrupt hills, with deep and narrow valleys interposed; and the cliffs and quarries shew that the rocks have a similar conformation. This cannot well be mistaken, for the layers of the slate, here, have not an uniform curve, but slope with a gentle sweep on one side, and rise abruptly, and even precipitously on the other: and the hills, more particularly those including the parallel east and west valleys, follow the same order; and their steep sides are uniformly those which are more remote from the granite. Towards the summit of the precipitous sides of these hills, the naked rock sometimes (as at Forrabury and Boscastle) protrudes in the form of broken and shelving layers, having very much the appearance of having been produced by the fracture and elevation of the strata; but I think that this can be explained by the manner in

* Vol. III. p. 7.

which the elements act on these peculiarly curved layers: on the gently sloping side of the curve, the disintegrated rock remains undisturbed in its native place; but every shower of rain washes away all friable and earthy portions from the precipitous side, and every winter's frost hastens the dilapidation by throwing down fragments from the same, as is indicated by the *talus* of *debris* at its base, and thus, in process of time, the ascending layers are removed, and the edges of the descending layers, belonging to the other side of the hill, become exposed to view. I am confirmed in this opinion, by the appearance of the rocks on the sea-shore at Pelly Point, near Boscastle: where the undulations of the layers represent the hills and valleys in miniature; and the laminæ on the abrupt side of the curves (which are always thinner and apparently less numerous than those of the sloping side) may be observed in every stage of destruction, and when entirely removed, the descending laminæ protrude in the same manner as the rocks on the large scale.

In assigning the origin of Cornish valleys to the peculiar structure of the rocks, I do not mean to deny, that the valleys of the adjoining counties have been produced by denudation, as described by Professor Buckland: nor, that some valleys have been excavated by fluviatile erosion; though it is probable that the influence of the latter cause has been much overrated. At all events the rivers of Cornwall (and indeed of the most elevated ranges of all countries equally limited in extent) could not

have been instrumental in forming the valleys, for they are insignificant in size, and have evidently, in all cases, accommodated themselves to the preexisting form of the country, seeking an outlet into the sea by the nearest continuous descent:—thus, when the granitic hills (in which the rivers commonly have their source) are near the sea, the course of the streams is pretty direct; but when they are more remote therefrom, the rivers do not discharge themselves by the shortest route. The Camel, for instance, rises about four miles from the sea, in the moors near Davidstow, and flows more than twenty-five miles before it empties itself into the sea at Padstow, in consequence of an intervening range of hills running parallel with the granite: in this comparatively long course, it only receives tributary streams on its left bank; whilst those that drain from the hills on the right bank, if they cannot find a direct outlet, run through the next valley parallel with the Camel.

The effects at present produced by the Cornish rivers, are confined to the conveyance of earth and other loose substances (generally received from the innumerable rills which flow from the adjacent steep hills during heavy falls of rain) which are deposited at their confluence with the sea, or sooner if the current becomes slow; so that, in fact, the rivers fill up, instead of excavating, the valleys.

In thus advocating the primordial origin of the Cornish valleys, it is not intended to assert that they have undergone no change; for it cannot be doubted that the solid rocks have always been subject to the

gradual, but extensive, disintegration now in active operation; and that those parts, thus rendered friable and earthy, must have been swept away by each successive *debacle*, of which visitations such ample memorials are to be found in this, as well as in other parts of the world. Such denuding powers, though they do not create, would certainly modify the previous forms of the valleys, by enlarging those, in elevated situations, and by partially filling up those, at lower levels, with diluvial deposits.

Such is the principal structure of the Cornish rocks: and the layers of the slate may be subdivided into laminæ which are generally parallel with the surface thereof; but sometimes, as at Penlee and the Nare Points, they cross the layers nearly at right angles. At Boscastle, the laminæ present a most curious arrangement, being disposed between the seams of the layers in a contorted manner, exhibiting the same complicated structure as the layers.

The rocks on the western side of Tregoss Moor, adjoining the granite of St. Dennis, also possess a kind of internal contortion in a preeminent degree; and it is particularly distinct, because the curves are not homogeneous, but consist of black and white stripes. These curves sometimes assume the most capricious forms which, oftentimes, are not unlike the marbled edges of a bound book: and it is curious to observe how distinct the colours are preserved, even when they do not exceed the size of the finest line. The nature, however, of these curves is widely different from those in the slate of Boscastle:

for the latter are formed of laminæ which are fissile in the direction of their contortions; whereas the former have no connection with the mechanical structure of the rock, (the cleavage indiscriminately crossing the curves as easily, as parallel thereto,) but appear to be owing to the colouring or accessory constituent being thus peculiarly arranged throughout the basis of the rock, during its formation.

How are these curves and contortions of the laminæ, and of the layers, of rocks to be accounted for?

Dr. Macculloch* states that the quartz-rock of Ben Gloe is contorted in the manner of mica-schist, "a proof that, like all other schistose rocks, it has occasionally been in a flexible state." This opinion that the primary schistose rocks were once in a flexible state, during which, their contortions were effected, is generally received; and I need only allude to Sir James Hall's† well known and very ingenious explanation of this phenomenon.

The facts, however, which have just been under consideration, appear to be incompatible with this opinion: for although it may explain the simple curvatures of the layers, can it account for the complex curves of the laminæ, between these layers? or, for the agate-like arrangement of the constituents in the rock of the Tregoss Moors? I think that it cannot: and that this curved and convoluted structure of rocks must be referred to original conformation, being analogous to the curved configurations so common in the animal and vegetable kingdoms.

* Trans. Geol. Soc. of London. Vol. IV. p. 267.

† Trans. of the Royal Soc. of Edinburgh. Vol. VII. p. 102.

This conclusion is in accordance with the observations of Mr. Weaver,* drawn from a similar district in the East of Ireland. "In the line of the Ovoca," he remarks, "although the general dip of the clay-slate is to the south-east, it sometimes appears to dip to the north-west, a phenomenon which I conceive to arise, in part, from simple inflection, or from lenticular masses, composed of concentric lamellar concretions, which being enveloped in the general body, and abrupted near the surface, present only sections to our observations. If we could follow their limits with the eye, we should probably find the fact to be as now stated; a view of the subject, which may tend to explain the apparent inflections and contortions of rocks in general; and perhaps, the stratified structure, in all its varieties, may be considered as resulting from concretion on the large scale."

ON THE VEINS OF CORNWALL.

I have already stated that I have purposely refrained from making enquiries, at the mines, concerning the phenomena of veins, in consequence of Mr. Henwood being engaged in an investigation of this important subject.

My experience, therefore, has been principally confined to those veins which occur in cliffs, in quarries, and in similar natural and artificial sections, that are exposed to open view; and, to an examination of the composition of veins, and of their connection

* Trans. Geol. Soc. of London. Vol. V. p. 175.

with the rocks which they traverse, as shewn by the fragments on the surface of the mines.

This admission may create surprise, more especially amongst well informed miners, that any one should make remarks on the veins of Cornwall, on such limited sources of information; but, in reply, I would observe, with the greatest respect for the interesting and important reports of practical men, that these sources are to us invaluable, as the only ones of which we can easily avail ourselves to examine with our own senses, the nature of veins; for unless much accustomed to descend into mines, they may as well be visited blindfolded.

From these sources, therefore, I have drawn the account of veins about to be detailed; some parts of which may, at first, be considered incorrect, since they are not in accordance with the general notions on this subject: but I trust that after a careful perusal, unbiassed by hypothesis, that this description will be found to be in accordance with Nature.

The veins of Cornwall have no determinate size: being sometimes very narrow, or exceeding several fathoms in width; extending sometimes to a great length and depth, or terminating after a very short course in either direction. As regards their form, they are occasionally, though rarely, contained within parallel and regularly inclined sides or *walls;* but are continually varying in width, both on the line of their course, and of their inclination; partaking often of the same undulating, and even curved, form of the rocks which they traverse: moreover, they

are accompanied on either side by innumerable branches, which extend in various directions. And lastly, a parallel series of veins frequently meets a cross vein, either on the line of its course, or of its dip: some of these veins continue their direction on either side of the cross vein; whilst others, on the opposite side of the cross vein, abruptly disappear, on the line of their original course, and are often found at some distance therefrom, but running in a parallel direction.

On a small scale, as in the granite of Carclaze, and in the slate of St. Agnes, these branched and intersected veins are beautifully illustrated: parallel ramifications may be seen departing from either side of the veins; and in the case of intersected veins, they sometimes preserve the same course on both sides of the cross vein, but often exhibit that peculiar arrangement, called by the miner a *heave*.

Veins vary very much in their composition: in general, they consist entirely of earthy minerals which, indeed, even when the veins are metalliferous, constitute the greater part thereof, the ores seldom being continuous for any considerable distance, but being scattered and disseminated throughout the *matrix*, in short irregular veins, layers, bunches, granules, crystals, and similar forms; sometimes indeed, but rarely, except in very small veins, the ore entirely prevails.

The prevalent idea of Cornish *lodes* is, I believe, rather imperfect; and those who suppose veins to have regular walls, and to have been derived from

fissures, would not recognise as such, layers of shorl-rock, of porphyry, of hornstone, and even of granite itself; but these are called *lodes* by the miners,* when they abound in metallic minerals. Even the most regular tin and copper *lodes* are very complex in their composition: quartz generally prevails in the matrix, but is always more or less blended, or mixed, with a substance similar to the adjoining rock; indeed the latter often occurs in distinct forms, as nodules, angular pieces, and even masses of considerable size, which are independent of the main rock, being completely enveloped in the quartzose part of the *lode:* these are of such common occurrence, as to have been named by the miners, *horses of killas.* Sometimes the schist so abounds in the *lode* that the quartzose part altogether disappears, or is only continued in minute strings; in this case the *lode* is said to have *dwindled away,* or to have been *wrung out.* It also frequently happens that both these principal parts (the rock and the quartz) are intimately united, producing a siliceous layer of rock which is still metalliferous, and is commonly called *capel:*—hence the courses of shorl-rock, porphyry, and some anomalous rocks, which have been called by the miners *elvans,* have been properly considered by them to be analogous to *lodes;* † for they are, in fact, veins on a large scale.

* "In Huel Unity, the *elvan* is so rich in tin, that it is considered as the tin *lode.*" Vol. II. p. 79.

† "Circumstances are strongly in favor of *elvan-courses* being true veins, of which they probably form one of the earliest classes." Carne on Veins. Vol. II. p. 88.

"the mineral contents of a vertical or inclined fissure nearly straight, and of indefinite length and depth:" "contemporaneous veins have been usually distinguished by their shortness, crookedness, and irregularity of size." In the extreme cases of each, this distinction might serve; but I think that it will be found that veins, whether mineral or metalliferous, exhibit every gradation of size, and every variety of form, between the smallest and the largest, between the most irregular and those the sides of which are perfectly parallel.

"The contents of true veins," continues Mr. Carne, "are generally, but not always, different from the strata or the rocks which the veins intersect:" the contemporaneous veins are distinguished "by the similarity of the constituent parts of the substances which they contain to those of the adjoining rocks, with which they are generally so closely connected as to appear a part of the same mass." Surely the veins of axinite, prehnite, serpentine, agate, and others, are not more similar, than the metalliferous veins, to the rocks in which they occur; nor do they exhibit a more intimate bond of union therewith, for although the *seams* or joints of *lodes* are sometimes lined with clay, yet the same also often exists between the layers of rocks, which is the result of decomposition effected by water which finds an easy passage through the joints. "Small branches are also frequently found to diverge from true veins on both sides." It is almost needless to assert that the contemporaneous veins also possess this character.

"When contemporaneous veins," adds Mr. Carne, "meet each other in a cross direction, they do not exhibit the heaves and interruptions of true veins, but usually unite." This statement is opposed to my observations, that the phenomenon of intersection is common to all kinds of veins; and I am confirmed in my opinion by what Mr. Carne says in continuation. "In a multitude of contemporaneous veins some may *appear* to be heaved, but the apparent heave seldom affects more than one vein, and it is in general easy to perceive that what appear to be separate parts of the same vein, are different veins which terminate at or near the cross vein." How is it to be ascertained that the *heaves* are not equally *apparent* in the case of metalliferous veins? Much remains to be learnt on this subject: but in the mean time some weight is due to the manner in which veins affect each other on a small scale, for all the circumstances are then subjected to our senses in one point of view; whilst on the large scale, the miner does not note all the variations in the mineral composition of the *lodes*, and of the rocks, at their points of contact, as his principal object is to find and obtain the riches which the *lodes* contain. I do not mean to assert that *lodes* do not exhibit the phenomena called *heaves;* but that this arrangement, as in the case of small veins, only gives the appearance to *lodes* of having been moved from their original positions.

Since, therefore, I cannot detect any characters which are not common to all the Cornish veins, and

since some of these are generally acknowledged to be contemporaneous with the rock, I conclude, that they have all the same origin.

On these grounds, it follows that the opinion which supposes *an intersected vein to be older than the vein by which it is traversed*, is necessarily dissented from. Mr. Carne has, on this hypothesis, attempted to divide his *order* of true veins into several *classes*. Veins certainly appear to form some very natural families; but these have been separated by Mr. Carne into several classes solely to dispose of the exceptions: thus, the tin and copper *lodes* have been divided into the oldest, and the more recent; and on the same ground another description of veins has been split into cross courses and cross flukans. But even after all, exceptions still arise:—a contra, for example, being heaved by an east and west *lode*, at Crenver: in like manner, *elvan-courses* are generally traversed by veins; yet at Polgooth, the reverse holds good. In short, unless a distinct class be made to receive each set of exceptions, the arrangement is defective; and by so doing, it would be rendered so complicated, as to be of no utility: indeed, at present, how are these oldest and newest classes of veins to be distinguished from each other? for all tin and copper *lodes*, if explored only between certain points, must be referred to the former; it is only after considerable research, that it can be ascertained in what manner these veins are intersected.

I shall have occasion to revert to this topic again before concluding my remarks on veins.

The conclusion, that the metalliferous veins of Cornwall are contemporaneous, is at variance with the opinion that veins were originally fissures, which is now so generally received, that Dr. Macculloch* when treating of the theory of veins remarks, that "the only important question at issue, concerns the manner in which the contents of veins were formed and introduced." Some veins may have had their origin from fissures; but this doctrine is not applicable, I think, to the veins of Cornwall:—their great irregularity in size, and in form, their frequent ramifications, their similarity of composition and intimate connection, with the rocks which they traverse, and above all, the large masses of slate which they envelope, (and which could not have been suspended in an insulated position, either in open fissures, or in the contents of veins whilst in a fluid state,) all these circumstances combine to disprove this hypothesis, and to support their contemporaneous origin. I may, in this place, state that in this opinion concerning the veins of Cornwall, I do not stand alone, for Mr. Henwood has also come to the same conclusion; and I understand that Mr. R. W. Fox has long been of the same way of thinking, and that he has lately attributed the direction of the *lodes* to the agency of electro-magnetism.

This may be the case, but if so, the arrangement of the layers, (strata) of the rocks themselves, ought perhaps to be referred to the same influence, for they appear to have been subject to similar laws. It has

* System of Geology, Vol. 1. p. 389.

often struck me, that the large veins correspond with the *seams* of the layers of rocks, and the smaller ones with those of the component blocks and laminæ of these layers; I have repeatedly detected this coincidence: this conjecture, however, requires to be put to the test of farther observations.

The correspondence between the direction of veins, and of the layers and laminæ of rocks, may require farther explanation, in order to make my meaning intelligible. Let, therefore, those layers of slate, which possess the most regular form and inclination, be taken for illustration: these, as already stated, consist of an aggregation of flat rhomboidal masses, and are inclined at various angles; so that the whole body of this slate is intersected by three sets of parallel joints or seams. Now quartz-veins, and some of the siliceous rocks (which, when they contain ores, have been called by the miner *courses of capel,* or *capelly lodes,*) are often arranged parallel with the largest surface of these layers. The granitic rocks, however, (commonly called *elvan-courses)* follow the joints of the schistose layers, that are inclined, at a greater angle, and generally dip towards the granite, when the slate has a contrary direction.* The metalliferous veins also occur parallel with these joints; † and likewise, with those, which cross them,

* "The *elvan-courses* do not always underlie in the same direction, and scarcely even at the same angle, as the dip of the slate." Mr. Carne on Veins. Vol. II. p. 82.

† "I have heard one of the principal miners in Cornwall express an opinion that the killas generally takes the same direction, as the north-west and south-east lodes, in the parish of Gwennap." Mr. Carne on Mining. Vol. III. p. 83.

nearly at right angles with the central masses of granite: and so it follows, that corresponding joints of the slate that are east and west on one side of the granite, become north and south at another part of the central masses of this rock; and this circumstance may, in some measure, account for *lodes* similar in composition to the east and west ones (as those of St. Just) being arranged in the position of *contras*. The position of the lateral branches of *lodes*, and of some small veins, may be assigned to the joints between the individual masses, of which the layers are composed: and the smallest veins appear to be disposed between the laminæ of the slate, as at St. Agnes; thus, the phenomena of intersection and heaves which the latter exhibits, are in accordance with this conjecture, as the laminæ possess the same structure on the small scale, as the layers of the slate.

If this analogy be correct it is justifiable to compare the greater with the lesser phenomena: and the latter, I think, no one would attribute to fissures and subsequent heaves.

This view of the subject explains why the different series of veins cross each other, and why the veins of each series are respectively parallel. And we may suppose, though we cannot give a reason for it, that some kinds of veins, in preference to others, may have preserved their course during the period of their formation: so that, those veins, which are crossed, may seem to *abut* or terminate against those that are opposed thereto; having when in the same line, that peculiar appearance that has

been attributed to intersection: and the appearance of having been heaved, when on the opposite sides of the cross vein, they are not on the same line, but occur in the parallel joints of distant layers:—the latter occurrence, however, although very common is not universal, for in some instances the part of the vein supposed to have been intersected, has never been found.

If the conjecture now advanced, and which is derived from the examination of veins on a small scale, should be found applicable to *lodes;* then veins, in general, might be arranged according to the description of rock-structure, with which they are associated: such an arrangement would correspond with some of the most important classes of Mr. Carne; thus, one kind of veins occurs parallel with the layers of the rocks; a second, runs the same course as the layers, but dips at greater angles, and in a different direction, including the tin and copper *lodes;* a third, intersects the layers at various angles with their course, comprising the cross courses and cross flukans; and a fourth kind is confined to what may be called the internal structure of rocks, viz. to the joints of the laminæ, and of the angular masses, of which the layers are composed.

In the examination of the phenomena of *lodes*, it would be desirable to observe more particularly, than has been hitherto done, the composition of the accompanying rock, and also of its mechanical structure: and preparatory to this, it will be necessary to study the perfect rock, at some distance from the

lode; and to note carefully the various transitions which it undergoes, when it approaches either *elvans,* mineral veins or *lodes,* or indeed, under any other circumstances; but above all, to ascertain the changes which each of these varieties undergoes during decomposition, for they must not be confounded with distinct varieties, as they often have been, under the names of red, white, and soft, slates.

On the supposition that veins have been arranged by electricity, or by a similar agency, we may fancy that certain currents were more powerful than those in a different direction, so that they interposed between them, producing continuous effects; by which, sometimes the weaker currents were diverted from their original course, or even intercepted altogether: we might also imagine, that these diverse currents would produce different mineral combinations, some containing one metal and some another.

But if the veins are contemporaneous with the rocks, we shall, I think, strive in vain to account for the manner of their production: for the Botanist might as well search for the cause of twigs and leaves being sometimes disposed on the branch, opposite to each other, and at other times, in an alternating position; or the Anatomist, to explain the endless varieties of ramifications in the vascular systems of animals. We must therefore follow the example of the cultivators of these sister sciences, and be content with endeavouring to obtain an accurate *description* of veins: this object is, in some measure, within our reach; the other far beyond our finite comprehension.

ON THE NATURE AND ORIGIN OF THE GRANITIC AND SCHISTOSE ROCKS.

In the description of the various kinds of Cornish rocks, and of their structure, it may have been observed that the division into *stratified* and *unstratified*, according to the established doctrine of the day, has not been adopted.

The principal reason for this dissent, is founded on the intimate connection which subsists between the porphyries and other compact (unstratified) rocks, and the slates (stratified rocks) with which they are associated: both of which, as has been repeatedly shewn, have the same mineral composition, and the same structure; occurring respectively in large layers or beds, which mutually coalesce by a gradual alteration in their mineral characters. On these grounds the terms *stratified* and *unstratified*, which imply not only a different structure, but also a dissimilar mode of formation, do not appear to be very appropriate to the rocks of Cornwall.

De la Beche,* although he has followed this division of rocks, is fully sensible of its objectionable character. "The minerals," he observes, "which compose the mass of these (the inferior) stratified rocks are precisely those which constitute the mass of the unstratified rocks." "And we find that the same elementary substances have produced the same minerals in both, the only difference between them, being their general difference of arrangement rela-

* Geological Manual. p. 465.

tively to each other; so that they constitute a stratified compound in the one case, and not in the other." "There is so much apparent mineralogical resemblance between these two classes of rocks, that we can scarcely refrain from conjecturing the remote origin of the one and of the other, to be in some manner connected, modifying circumstances having impressed certain characters on each."

Dr. Macculloch, on the other hand, who has recorded numerous and important facts bearing on this subject, strives to explain the intimate connection of these rocks, in order to disprove their identity. For instance, in the case of granite and gneiss, (which in composition are undoubtedly similar, and exhibit mutual transitions into each other more distinctly characterized than any other rocks,) he has remarked* that "the granite which occurs in an apparently regular stratification with gneiss, has aided in giving rise to the opinion that granite is a stratified rock." But this does "not prove the stratification of granite, which possesses characters not to be mistaken; while on considering the near approach to a granitic stratum which gneiss so often undergoes, it can excite no surprise to find the foliated disposition occasionally disappear." This Author had previously observed† in the description of granite, that "no instance of its stratification has been produced, notwithstanding the repeated assertions of this nature; nor can it exist, consistently with the meaning of that term. It is true, *that beds of gneiss cannot*

* System of Geology. Vol. II. p. 149. † Idem. p. 93.

sometimes be distinguished from granite; but these are only extreme cases of a stratum which, in granitic gneiss, "frequently approaches to the character of granite."

Thus it appears to me, that much ingenuity is expended to prove that granite is not granite, but granitic gneiss: because, if the origin of these rocks were admitted to be identical, it would overturn the hypothetical application of the term stratification.

Although Dr. Macculloch thus attaches little importance to mineralogical transitions between the *stratified* and *unstratified* rocks, yet between the individuals of the latter class, he maintains the validity of the inference, that rocks passing into each other are identical: for the transition of granite and trap, forms the last step in his proof that granite is of igneous origin.

On similar grounds, as those which indicate that the compact rocks and the slates of the schistose group, are contemporaneous, it may also be concluded that the granitic and schistose groups have the same composition, and are of coeval formation.

It has already been shewn that the slate, in immediate contact with the granite, consists of a compound basis of felspar and quartz, united with mica, or some mineral analogous thereto; and, that it gradually becomes harder and more massive, whilst the granite also undergoes a corresponding change, being, generally, finer grained and more compact, resembling the granite of veins: thus both rocks, in many places, insensibly graduate into each other;

and oftentimes they adhere so firmly together, that they cannot be separated without much violence.

This occurrence is not peculiar to Cornwall, although it may be, perhaps, more advantageously studied here in the numerous mines, and in the sections on the sea-shore. In other countries, it may be often seen at the junction of granite with gneiss and mica-slate; and Dr. Macculloch mentions* an instance of it in quartz-rock. "The beds of this rock," he says, "which are in immediate contact with the granite, often pass into it by insensible degrees: and it is not, therefore, surprising that it should, like the mica-slate, with which it forms but one great deposit, undergo analogous changes, when it approximates to this rock. The transition is more easy since many varieties of quart-rock, formed of felspar and quartz, in varying proportions, with occasional mixture of mica, only require to assume that crystalline appearance, to become undistinguishable from it."

The intimate relation of granite and slate, is also proved indirectly, by the passage of the most perfect and crystalline kind of the former into beds of porphyry, shorl-rock, and other granitic genera, by which it is traversed; and which also occur in the slate, exhibiting the same mutual connection. Small concretions and patches, resembling the various kinds of schistose rocks, are often found in the granite of Cornwall: and an interesting occurrence of this nature has been recorded by Mr. Majendie,†

* Trans. Geol. Soc. of London. Vol. IV. p. 268.

† Vol. I. p. 29.

who saw at the Logan Rock the large crystals of the porphyritic granite penetrating into the imbedded concretions of fine-grained granite and of shorl-rock.

Thus we learn, that all the primary rocks of Cornwall, even including the granite, are of similar composition, and probably of contemporaneous origin: and, that the geological law of Conybeare,* already noticed, is likewise applicable to the granite and the slate, although, perhaps, its author did not contemplate its extension thereto.

But how have these rocks been produced? I should have avoided this topic altogether, as being too speculative, but I cannot refrain from stating my dissent from the doctrine of the igneous origin of granite. which has been so generally adopted, that it appears to be regarded as an established theory. The writings of the most eminent geologists, continually make mention of rocks having been converted into siliceous schist, and otherwise altered, by the contact of granite and trap rocks, whilst in a state of igneous fusion: such hypothetical language must, I think, be prejudicial to the progress of this science, by teaching the student to regard as facts, what is only matter of opinion; and thus preventing a deliberate and unbiassed investigation of nature.

It is proposed, in the first place, to state briefly the principal objections to this doctrine; and then, to endeavour to shew that the validity of the arguments, by which the igneous origin of granite is supposed to have been proved, may be disputed.

* See page 385.

The peculiar condition of granite and slate, at their junction, has, in the preceding pages, been considered as the connecting link of the chain of transitions, by which these rocks mutually pass into each other. In confirmation of which, it may be stated, that these rocks always exhibit an intimate relation towards each other, which could not be expected if the granite were an independent formation, protruded subsequently to the existence of the schistose-rocks.—Thus, when the granite is very crystalline, and contains beds of felspar-porphyry, the adjacent slate is hard and felspathic, (see cornubianite) and also abounds in the same granitic beds; when, on the other hand, the granite is more micaceous, and contains beds of eurite, then it is succeeded by a softer slate resembling mica-schist; and lastly, when shorlaceous granite occurs at the junction, the slate is also combined with shorl, producing a rock distinct from either of the former slates, and abounding in shorl-rock, as does also the shorlaceous granite.

It may be farther observed that the various beds of granitic, and of compact rocks, associated and alternating with the slate, display similar phenomena at their junction with the latter: so that, if all these massive (unstratified) rocks have been protruded in a state of fusion, the whole of Cornwall must have experienced innumerable, and almost contiguous, fractures and injections. But neither these massive rocks, nor the slate, exhibit indications of such convulsions, for the *seams* of the layers, of both rocks, follow their peculiar courses in a regular

manner:—and indeed, in many instances, the massive crystalline rocks are found completely insulated in the slate, and *vice versâ*.

It has been frequently mentioned, in the preceding pages, that both the granite and the slate, in contact with the large quartz-veins, are subject to the same altered appearance: on the igneous doctrine, these veins ought also to be referred to the same origin as granite and trap; a conclusion rather embarrassing, when we regard the endless number of these veins, and the almost infusible nature of quartz.

If I mistake not, the advocates of this hypothesis have brought forward as a proof of the protrusion of granite from beneath, the abundance of metalliferous veins near the junction. This, however, is only endeavouring to make one conjecture establish another: but even admitting, for the sake of argument, that veins were originally fissures, we shall then see that instead of these having been produced by the rupture of the slate during the elevation of granite, that they must have existed antecedent to such a convulsion; for the largest (and what is commonly called the *oldest*) veins are very frequently found, in Cornwall, to continue their course uninterruptedly, through both the granite and the slate.

Since, therefore, the granite could not have been the cause of the fissures in the slate, having been itself equally effected thereby, we must search in the slate for other marks of this supposed convulsion. The layers of this rock, however, are, next the granite, regularly inclined; and not unfrequently at less

angles, than when remote therefrom. And lastly, it must not be omitted to mention, that occasionally a bed of granitic rock, forming an integrant part of a central mass of granite, extends beyond the boundary thereof, and traverses the slate, with which it experiences the same transitions, as occur at the regular junction of these rocks.

From these facts, it appears to be a justifiable conclusion, that the granite has not been protruded from beneath, through previously existing beds of schistose rocks; but, that both the granite and the slate have one common origin: whether this, however, be igneous or otherwise, remains to be ascertained.

Dr. Macculloch, in his excellent account of the granite of Aberdeenshire, contends for the igneous origin of this rock: I may be in error, but it appears to me that the deductions, by which this conclusion has been arrived at, are imperfect.

It cannot be denied that both the trap and the granite, which mutually pass into each other, have one common origin; but it does not follow that this origin is volcanic, because the trap perfectly resembles some kinds of lava: nor is this proved, because in the furnace these substances may be respectively converted into each other, and also be reduced to their original condition: for this fact only shews that the lava and the trap are indestructible by fusion; and that the lava, resembling trap, may have been produced by the volcanic fire having operated on rocks of this description.

It is possible indeed, that these rocks (trap and

granite) may have been originally formed from fusion: but then on the foregoing conclusions, all the primary rocks, including the magnesian and other infusible substances, must have had a similar origin.

One thing, however, is evident (reasoning on analogy) that during the formation of the crystalline rocks of this class, their elements must have had a free motion amongst themselves, either through the agency of caloric, or some other cause. And, as a central cluster of crystals is formed in a lamellar mass of bismuth, on slowly cooling from a state of fusion, so in like manner, might the primary rocks have been produced: the repulsion between the particles being gradually overcome by the power of attraction, the various minerals would be first formed, and then united in different proportions; the aggregation, probably, commencing at the groups of granite, and from these central points extending to the extreme parts of the schistose rocks. But we have now advanced beyond the bounds of legitimate deductions: we may examine the composition and the structure of primary rocks; and by carefully observing the changes to which they are now subject, we may be able to account for many of the revolutions which they have undergone through the influence of secondary causes; but in attempting to explain the nature of their origin, we endeavour, I think, to pass that point, so common in all the works of the creation, beyond which we are lost in vague, though fascinating, conjectures.

ON THE SECONDARY OR DERIVATIVE CLASS OF CORNISH ROCKS.

To complete the geological account of Cornwall, it only remains to describe this class, which includes, besides the fragmentary rocks, the alluvial and diluvial deposits.

These rocks are of very inconsiderable extent, being found only in two places: one, near the Nare at the entrance into Helford Harbour; the other, at Cawsand, near Mount Edgcumbe. The rock, at the latter place, resembles a red argillaceous sandstone: whilst at the former, it consists almost entirely of greywacké, including a conglomerate of rolled pebbles which sometimes exceed several inches in diameter, and are composed of slate traversed by quartz-veins, or solely of quartz, and of siliceous varieties of slate, derived from the harder parts of the adjoining strata, to which they are exactly similar; the basis or cement by which these pebbles are united, has evidently proceeded from the softer parts of the same strata. The nature of the Cawsand sandstone is not so easily decided on, but it appears to have been derived from the siliceous particles of the adjoining slate, and from the compact rocks that are imbedded therein.

It is worthy of remark, that these rocks are both situated on the sides of extensive Harbours: and, that in both cases their component parts have not been transported far from their source; in which respect they agree with *some* of the diluvial deposits which line the Cornish coasts, and a portion of which has been partially consolidated.

Thus we have a repetition of the same phenomenon at periods, in all probability, very remote from each other; since one deposit has attained a degree of solidity, fully equal, and in some cases superior, to that of the parent rocks: and another circumstance regarding these rocks of Cawsand and Helford, must not be omitted; viz. that their internal structure is similar to that of the primary rocks, being divided, by parallel joints, into distinct layers and masses. This occurrence, in rocks of decidedly mechanical origin, appears at first very perplexing; since, however, the same cohesive power has aggregated the particles of both kinds of rocks, we can conceive that a similar result would follow, though effected under different circumstances.

The geological era of the Cawsand rock, is marked by the fossiliferous limestone of Plymouth, with which it is associated, and which belongs to the *grauwacke group* of De la Beche: the rocks of Helford probably belong to the same formation, but they do not appear to contain organic remains.

The various deposits of clay, sand, and gravel, that occupy the bottom of the deep valleys, and the sides of the hills, in Cornwall, form a very interesting subject for enquiry. It is evident that these have not been produced by one catastrophe, for they afford records of several distinct convulsions which, according to the evidence adduced from the secondary and tertiary rocks, have periodically revolutionized the surface of the earth.

In treating this subject, it appears to me, that the

most desirable plan is, in the first place, to examine the changes which are now taking place; and then to trace back, if possible, the various deposits, beginning with the most recent.

The mechanical action of the atmosphere does not, in Cornwall, effect such important changes, as the chemical. Frost sometimes separates and throws down the laminæ of the schistose rocks, to the foot of the precipice; high winds blow loose sand beyond its previous limits, so as to overwhelm, occasionally, a portion of the adjoining pastures; and heavy rains, in flowing over the steep hills, become charged with argillaceous particles, which are again deposited at lower levels: but neither of these causes produce much alteration in the surface.

Nor are the operations of rivers, in this county, of any moment; their effects are confined, in a great measure, to the transport of earthy particles, during the rainy seasons, by the deposition of which their beds, near the estuaries, are gradually elevated: these beds of alluvion are of little extent, but it is necessary to observe their nature, because we shall have occasion to notice similar depoits belonging to another and earlier epoch, and containing both fresh water and marine shells.

The sea is a more active agent of destruction; and its encroachment on these shores is progressive, both on the sand-banks, at the head of the bays, and on the cliffs of solid rock.

When the waves attack the banks of sand, and of gravel, in open bays, the degraded portion is

removed some distance from the shores; but in narrow estuaries, the sand-banks, thus broken down, are levelled over the whole channel, and the portion carried sea-ward is accumulated at the mouth in the form of a bar: the former case is illustrated at Mount's Bay; the latter at Hayle, and between Par and St. Blazey. On the other hand, when the sea assails the solid cliffs, its progress is more or less rapid, according to the nature and structure of the rock. In granite and other massive rocks, it first removes the softer parts, producing caverns, by which the mechanical power of the waves is increased: and this operation proceeds until the adjoining masses are thrown down and separated at the joints into angular blocks, which, by subsequent attrition are rounded into bowlders, and form a sloping *talus* at the foot of the cliff. In schistose rocks, much depends on the direction in which the sea carries on the attack: if the laminæ dip towards the sea, the cliff is generally low, and the slate makes the strongest resistance to the waves; but if the rock inclines in an opposite direction, the sea will gradually undermine the cliff, and the upper part, deriving support from the overlapping of the laminæ, will overhang considerably before it falls: and the destruction in this case, though often extensive, is not so great as when the rock is breached across its layers, where it is divided by joints nearly perpendicular; as in the instance already noticed between St. Agnes and Cligga Point.

Such are the mechanical effects of the elements,

now in operation, on the Cornish rocks; but these, collectively, do not produce any considerable alteration in the form of the country.

I will not detail the various chemical changes effected by the direct influence of the atmosphere; such phenomena have been often described, and are well understood. But I must repeat what I have elsewhere* stated, that the decomposition of rocks is accelerated, when the atmosphere is excluded by a covering of soil; and, that this fact may be thus accounted for:—the air that exists in rain-water, contains a larger proportion of oxygen than the atmosphere, and is brought into contact with the constituents of the rocks, in a condensed liquid form, a condition so much more favourable to chemical action than the gaseous state, that it might be expected to produce a greater effect than the direct operation of the atmosphere.

In the same place I attempted to prove, that vegetation, by fixing the soil, promotes the decay of rocks: this is at variance with the general opinion which ascribes to it a protecting influence; and appears to be opposed to the well known fact that artificial mounds of earth, or barrows, have not, after the lapse of two thousand years, experienced any material alteration of form, although only covered by a short turf; but this circumstance only proves that the loose materials, of which these barrows are formed, have been effectually protected by the turf from the *mechanical* action of wind and rain.

* Vol. III. p. 22. et seq.

This decomposition of rocks, though slow in its progress, and in a great measure concealed from view, tends eventually to produce a greater alteration on the surface of the earth than any other cause, with the exception, perhaps, of volcanic fires: for when we consider that all rocks are more or less disintegrated, and in some instances to a depth of many fathoms, it is easy to understand the effects which would be produced thereon by one of those *debacles*, which have periodically visited the Earth.

The most recent of these catastrophes, has left traces of its existence in almost every part of Cornwall. The diluvium, thus produced, rests on, or near, rocks of the same nature, having been transported, in most cases, only to the lower part of the hill, or into the adjoining valley; so that this deposit gradually diminishes in depth towards the summit of the hills:—thus the granitic *debris* extends over the adjacent slate, without being blended with that of the latter rock which, very frequently, has not been removed, but is indigenous: this is not always easy to decide, when the transported *debris* has been derived from the same kind of rocks as the indigenous. If, however, a large section be exposed, the veins or harder parts will be seen traversing the rock and inferior *debris* in a regular manner, but terminating at the diluvium; and in low situations a layer of pebbles or of sand will be often seen interposed, which removes all doubt on the subject.

From these circumstances it may be concluded that the power by which this diluvium was produced,

must have acted not only generally, but suddenly, and for a short time; for if the *debris* had experienced a distant transportation, the earthy and stony substances, which are intermixed together, would have been separated from each other, and deposited according to their specific gravities.

This most recent diluvium generally reposes on the solid or disintegrated rock; but sometimes it covers older deposits of diluvium, which differ very materially from those just described: the fine and coarse parts of the latter have been separated into beds of clay, sand, gravel, and bowlders; the harder parts are more or less rounded according to their situation, some being more removed from the parent rocks, and others having evidently been subjected to the action of the waves, subsequently to their formation; sometimes these deposits are homogeneous, but more commonly they have been derived from various kinds of rocks.

Hence it may be concluded that this diluvium was produced by a more powerful *debacle* than the first. Some of its beds exhibit marks of having once existed under the sea, but they are now elevated above high water-mark: indeed this occurrence is frequently met with on the Cornish coast, and has also been observed at Plymouth and Torbay, and has been considered to be an ancient beach. The layers of granitic pebbles and bowlders, in the cliffs of the Land's End district, (which have been minutely described by Mr. Carne*) often occur far above the

* Vol. III. p. 229. et seq.

sea, and belong to a beach of the same description.

It is not easy to ascertain the maximum height of this ancient beach, it probably exceeded fifty feet, and from this point sloped gradually down beneath the sea, in the same manner as the present shore. Thus also the beds of gravel and sand at Fistral and Gerrans Bay, and elsewhere, exhibit the same phenomena, the lower part of these sometimes touching the waves; and at others, appearing in the cliffs resting on the rock, far above the present sea-level.

These facts appear to prove, that many of this series of diluvial beds were once submerged: and if so, this circumstance will account for the different appearance of these deposits and others far inland, which I am inclined to refer to one common origin.

The conglomerates, and sandstones, so common on these coasts, belong to this formation: and are therefore older than the beds of transported *debris*, which have been attributed to the action of the most recent *debacle*. I lay some stress on this assertion, because these recent rocks have been quoted, both by De la Beche and Lyall, as sand-beds, now in the course of production and consolidation: and as their remarks apply only to the calcareous or testaceous sandstone, I will endeavour to explain the state of the case.

On the northern shore are considerable sand-banks, consisting principally of comminuted shells: these banks are confined to the mouths of rivers, the upper part of bays, and other inlets of the sea. From these places, the loose sand has been carried by the wind inland, so as to cover even the adjacent

hills: forming drifted sand-banks, which may indeed be considered as alluvial beds, produced by causes now in action; but the original banks are not of this nature, any more than the diluvial gravel, at the bottom of some rivers, is of the same origin as the superincumbent mud or silt. It is the diluvial deposit of pebbles and sand, (produced by the second *debacle*, now under consideration) that is occasionally consolidated, and not the "sands transported from the beach into the interior," as stated by De la Beche.* Natural sections in the cliffs at Godrevy Point, and in several parts of Fistral Bay, clearly demonstrate this assertion:—on the rock (above high water-mark) rests a bed of pebbles, and above this another of testaceous sand, then follows a deposit of more recent diluvium (that is, of transported, but unaltered *debris,)* which is covered by turf, and above all is a layer of drifted sand.

Thus far it has been seen that Cornwall has been visited by two *debacles*:—by the *ultimate* one, the disintegrated parts of the rocks were not carried far from their native spots; but by the *penultimate debacle*, the *debris* was transported to a greater distance, and deposited in deep valleys and in low levels, where they have been subject to the action of the waves, to the height of about fifty feet above the present sea, as indicated by their being converted into gravel and sand; whilst at higher levels, they have supported vegetation, and been liable to the same atmospheric changes, as the present surface.

* Geological Manual. p. 77.

The condition of Cornwall during the period immediately preceding the penultimate *debacle* must have been very different from what it was after this catastrophe: for the sea instead of then being fifty feet above, was more than this beneath, its present level; as is proved by the subterranean forests, which in several *stream-works* have been found at this depth. Some may be of opinion that these remains were derived from rafts, such as those of America, described by Capt. Hall: it may, however, be observed that in Mount's Bay, at Pentewan, and elsewhere, some trunks of trees have been found in the vegetable bed, in a natural position, with the roots descending ten feet, or more, into the diluvial stratum beneath;*—and, moreover, these remains are not confined to the shore, but wherever the deposits of the penultimate *debacle* occur in the upland valleys far from the sea, they are always found resting on a black stratum composed of trees, plants, and other vegetable remains.

This appears then to establish the fact, that when Cornwall was overwhelmed by the penultimate *debacle*, the valleys, low grounds, and other sheltered spots favourable to the growth of wood, were covered by forests: thus also shewing that a considerable period must have elapsed between their destruction, and the origin of the strata, on which they grew.

We have now arrived at the deposit of the *antepenultimate* epoch, the period of the earliest *debacle* of which any traces have been hitherto detected in

* See Mr. Colenso's paper on Pentuan Stream Work.

Cornwall, if we except the conglomerates and sandstones coeval with the Plymouth limestones. This deposit consists for the most part of pebbles, bowlders and fragments of all the rocks that occur in the space intervening between it and the central ridge of granite: earthy substances, and clay in small quantities, are also intermixed therewith, but these have probably been derived from the subsequent decomposition of some fragments of rock: this deposit is also characterized by its containing a large quantity of tin-ore; on which account it has been extensively explored, and has thus been instrumental in unfolding much curious information, which would have otherwise been undiscovered.

The *debacle* of this epoch appears to have been more powerful than either of the former, because it has removed heavy bodies farther from their source, and has swept the finer parts of the decomposed rocks far beyond the limits of the present land. We have thus seen that the power of these periodical *debacles*, like that of volcanic fires, has been successivly diminishing in energy: so that the superior violence of the earlier catastrophes probably swept away all vestiges of the older series of *debris* far beyond the Cornish shores; and this may explain why countries which have a wider range, or are more distant from the central masses of primary rocks, possess diluvial beds more ancient than the stanniferous deposits.

Now let us consider whether these deductions will account for the phenomena of this lowest and oldest deposit, commonly called *stream-works*.

The gravel containing the tin-ore *(the tin-ground)* rests either on the solid rock, or on *indigenous debris* produced subsequently to the deposition of the diluvium: and the *tin-ground*, with very few exceptions, is covered by a stratum of black vegetable remains. Thus far the phenomena are common to all the principal *stream-works:* viz. a diluvial bed derived from the *debris* of rocks which intervene between it and the central ridge of granite; and the remains of vegetation with which the diluvial mass appears to have been generally clothed. We find that these remains, in the *stream-works*, are buried under another diluvial deposit:* in those that are far inland, the fine and coarse diluvium are intermixed, are not much rounded by attrition, and are often inferior to another bed of vegetable remains; whilst near the sea-shore, this diluvium is often separated into beds of rounded gravel and of sand, contains marine remains, shewing that it was once submerged, and lastly, it is covered by a deep deposit of *silt*, interstratified with layers of river and marine shells, and promiscuously mingled with the bones of land animals, and the trunks of trees; in short, with various substances such as commonly occur in estuaries. This fact is confirmed by the ancient beach which corresponds with the deposit; thus indicating a rise in the sea-level of more than one hundred feet; i. e. from fifty below, to fifty above, high water-mark.

* This diluvium, in some *stream-works* situated on the granite near the highest hills, rests on the rock and forms the *tin-ground:* the reason of the oldest diluvium being wanting, appears to be owing to the violence of the former *debacle* having swept the *debris* farther off, leaving behind only blocks and loose masses of granite.

Lastly, above all the preceding beds, we find another deposit of transported *debris*, which is sometimes very deep, but is frequently very shallow, or even altogether wanting: these variations, however, are readily explained by the situation of the *streamworks*, and the knowledge that this diluvium has not been transported far from the parent rocks. This deposit must have been accompanied, or succeeded, by a fall in the sea-level, or by an elevation of the land, for several marine beds of sand and gravel, belonging to the preceding diluvium, are now situated fifty feet above the sea.

Almost all the diluvial deposits individually furnish many interesting particulars; but I must defer this subject for the present, as it would very considerably augment this communication, which has already extended to a much greater length than I had anticipated.

Before concluding, I feel myself called upon again to apologize for the numerous innovations which I have ventured to propose, in the preceding pages. As regards the new names of rocks, I have no expectation that they will be generally adopted: indeed, I merely used them to point out, in a more marked manner, those rocks which appeared to me to form distinct genera, not altogether undescribed, but which have not hitherto been accurately discriminated. Should, however, any of the deductions,

by which I have endeavoured to disprove some received doctrines, be admitted by geologists, I shall feel gratified by such a token of the approbation of my labours: but concerning the fate of my hypothetical views, I have no anxiety; so deeply am I impressed with a conviction, that all the existing geological opinions must successively yield to others, as we become better acquainted with the Earth's structure.

This progressive advance of our Science must be step by step, by facts accumulated in all parts of the world: and I shall, therefore, be amply compensated for all my toil, if, in promotion of this great object, I have made some CONTRIBUTIONS TOWARDS A KNOWLEDGE OF THE GEOLOGY OF CORNWALL.

Since the foregoing pages were printed, I have seen, in the Museum of the Geological Society, the fossiliferous slates from Snowdon and Tintagel, and found that I was mistaken in supposing that these specimens were not accurately depicted in their Transactions. These shell-like impressions are for the most part concave, whereas all those which I had previously seen are convex; but this is not the only difference, for the rocks in which they respectively occur, are dissimilar:—the rock with the convex impressions, is connected with the Delabole roofing slate, whereas that with the concave, appears to belong to the series of shale containing layers of a carbonaceous mineral. I cannot, however, assert that this is positively the fact. It is my intention to revisit Tintagel, and I will endeavour to obtain more satisfactory information on this interesting subject.

XIII.—*Some account of the soft Growan at the Beam mine, in the Parish of Roche, and at Carclaze mine, in the Parish of St. Austle.*

By JOHN HAWKINS, Esq. F.R.S, &c.

VICE PRESIDENT OF THE SOCIETY.

(Read October, 1830.)

In the Memoir, which I communicated last year to this Society, on the subject of the china-clay pits, I hazarded an opinion on the nature and formation of the soft growan, which being perfectly new in the history of geological science in this country, may be thought by some to be premature, and by others, perhaps, unwarranted. My communication, however, had scarcely been read, before I received the information of a fact which very strikingly corroborated the opinion which I had formed, namely, that at the Beam mine, in the Parish of Roche, the works are actually sunk alternately through the hard and soft growan, greatly to the annoyance of the miners, who are obliged to use a great quantity of timber to keep open their shafts and levels, and even to caulk the apertures, to prevent a deluge of white clay from interrupting their labours.

I have lately availed myself of an opportunity of visiting this singular mine, where I found this information confirmed for the most part by the evidence of the mining captains, from whom I collected the following particulars.

I must previously observe that the Beam mine is situated on the eastern flanks of Hensborough, one of the highest hills in this county; and that the surface of this hill is principally composed of soft growan, for the clay-pits lie scattered over it in every direction. In some of these pits I observed the small shorlaceous tin-lodes, which so peculiarly belong to the Cornish granite, most of which, in consequence of the facilities afforded by the soft nature of the rock, appear to have been worked at an early period. All these lodes run nearly in the same direction: those at the Beam mine south-west by west, by the compass.

Four of these parallel lodes occur here at a short distance from each other, underlying at an angle of 45°. to the north. Like all the veins which traverse these hills, they are composed of quartz and shorl, carrying more or less tin, which substances are so united with the soft and hard growan, that not a doubt can be entertained of their contemporaneous formation. These, which may with more propriety be denominated veins than lodes, are usually very small and solid, and they are not dislocated or disordered as they pass through the soft growan, although in such situations they are observed to be bigger, and more productive of tin. There is one

cross course here, which heaves the lodes from three to five feet to the north; but there are no slides. I have since procured from one of the captains of this mine three well drawn transverse sections of the four lodes, represented at three different points of the workings, and in these sections have been marked at my particular request the respective positions of the hard and the soft growan.

It appears from these sections that the hard growan occurs no where in the upper levels of the mine, and that it occupies a small portion only of the lower; that it alternates with the soft growan; that it is not always found at corresponding levels; and that, in some instances, it terminates abruptly in a line which corresponds with the underlie of these veins.

These sections are the more interesting, because the mine, in consequence of its poverty, is now on the point of being abandoned.

In the course of the same day that I visited the Beam mine, I had an opportunity of examining several clay-pits, which I had not before seen, on the western as well as the eastern sides of Hensborough, and on the hills of St. Mewan, all of which present the same phenomena which I had before noticed; and all of which I regard as strongly corroborative of the opinion I had formed. But the most striking evidence of the aboriginal existence of the soft growan is perhaps that which is displayed by the celebrated excavation at Carclaze, in the Parish of St. Austle, which I have recently examined. The extent of ground which is laid open here to the depth of

twenty-three fathoms is not less than six acres, and it is almost wholly composed of soft growan, through which runs a numerous assemblage of shorl and quartz lodes in the usual direction. These, as they carry tin, are the sole objects of mining adventure, and the removal of the soft growan is effected by a stream of water which conveys all the refuse of the mine through the adit. I believe there is no other instance of a mine so worked, or of a mine, the working of which is attended with so little labour.

In respect to the lodes or veins which are so numerous here, this mine would be called by the Germans, a stock-work, but as far as regards the soft growan which contains these veins, it may not improperly be called a clay-pit. As for the composition of its mass, this growan exhibits no marks of sedementary or of stratified divisions, and if we direct our attention to the arrangement or distribution of its constituent parts, it differs in no respect from the hard growan. In short, there are no traces of any change or disturbance, and every part of the mass seems to be in the same state of induration; the lodes too which traverse it, bear, like the same lodes in the Beam mine, no marks of either dislocation or displacement, and moreover, so compact is the mass of this soft rock, that I conceive it hardly possible for any rain to penetrate through it, without which it is difficult to support the hypothesis of a decomposition.

The following particulars respecting the hard and soft growan of the Beam mine, I have since procured from Captain Samuel Robins.

There is no reason whatever to believe that any water can filter through the soft growan. It is only when we meet with a lode or a cross course, that we meet with any water. We have sunk from ten to fifteen fathoms through the soft growan without meeting with any water, and were it not for the lodes or cross courses we should find none. As a proof that the water proceeds wholly from the lodes and cross courses, it is first perceivable in the growan on that side of the lode which is first cut. Upon the whole we have not half so much water as is usually found in a killas country.

Whenever we meet with a lode, or even a small branch of one, we have water, more or less according to circumstances, the large hollow lodes carrying more water than the small or solid ones.

The mass of soft growan cannot be called dry; neither is it moist; but it is every where much in the same state as it is near the surface, a little damp.

The running of the white clay which obliges the miners to caulk all the boards of the shafts with heath, sedge, grass and moss, is occasioned by the water which is brought down by the lodes and courses.

There is not much difference in the quality of the soft ground, except near the lodes and cross courses, where it is much softer: this softness is perceivable at the distance of three or four fathoms from the lode on either side, and indicates to the miners the vicinity of a lode or cross course. In no other case does this ground vary in hardness, except where it changes almost at once to a hard rock. It is

worked by the pick and shovel, and at the same cost. The hard growan, however, varies extremely in its hardness:—some portions of it cost £60 per fathom working: others not more than £20; but in respect to its composition, it is perfectly like the soft growan. Some of the hard growan, which has cost £30 per fathom, after being exposed for a few months to the weather, has dissolved completely into a soft growan.

The soft growan is no where hard enough to support itself.

The hard growan is jointed in all directions.

NOTICES.

1.—*Notice of Wood and Peat found below high water-mark on the beach at Mainporth, in Cornwall.*

Communicated by

THE REV. JOHN ROGERS.

THE piece of oak and the peat which accompany this communication are from Mainporth beach, which divides the parishes of Budock and Mawnan. The oak is part of a stump, standing about a foot above the level of the sand, apparently in the place where it grew. It is just one hundred yards below high water-mark. On further examination I found the root of an oak laid bare, thirty yards below the stump: and at a spade's depth below the surface of the sand. Immediately adjoining the roots of oak, is the peat; I could trace the root extending about seven feet horizontally. The peat was evidently formed in marshy ground, and contains, I think, the leaves and roots of the *iris pseudacorus*—the common yellow flag, which grows in the adjoining marsh. I was informed by a respectable neighbouring farmer,

that he has seen the roots of oak and withy full thirty yards below the last mentioned oak; and I have often, after a storm, seen pieces of peat, washed in on the beach. In the first volume of our Transactions, page 236, a similar discovery is mentioned, made at Porthleaven. Soon after the sand-bank had been removed, to form the present harbour, I there observed, a little above low water-mark, several stumps of oaks and willows, with their roots extending through the mud which rested on the solid killas rock. Supposing these oaks and willows, when discovered, to have occupied the situation in which they grew, (which there is every reason to believe) their situation so far below the high water-mark must, I think, be attributed to one of the following causes: either a subsidence of the soil in which they grew must have taken place; or the trees must have grown in ground lower than the level of the sea, and protected from its aggressions, like the low lands of Holland, by a natural or artificial embankment; or the level of the sea must now be higher than it was when the oaks and willows grew in their native soil. The second supposition is the least probable of the the three. The subsidence of the soil, has been a favourite theory to account for the situation of the roots and trunks of oaks deeply imbedded in the sands of the Mount's Bay. But it is only by collecting and comparing a variety of facts that we can advance safely towards a rational and probable theory. Cornwall is not a county which has ever, as far as we know, been subject to volcanic action.

An extensive subsidence of the soil is, therefore, not probable, *a priori:* nor is there any thing of the kind known to have happened. The two bays, Mainporth and Porthleaven, are bounded by killas rock, in which there is no appearance of subsidence or dislocation: and at Porthleaven the roots were imbedded in clay, resting on the solid rock. It would be rash to assume, on the evidence of these three facts, that the sea has risen above its ancient level: but this appears to me, at present, the most probable hypothesis. In a county so abounding with bays and harbours, similar facts might, perhaps, be collected, and particular circumstances might be detailed with such accuracy as might lead to some general result. It would be important to ascertain, for instance, 1st. whether the stumps and roots are in the situation in which they originally grew:—2nd. at what distance they are situated, both in length, and in perpendicular depth, from the ordinary high water-mark:—3rd. whether accompanied by peat; and if so, of what leaves, roots, and other vegetable substances the peat appears to be composed: and 4th. whether any marks of subsidence are discernible; and whether any tradition exists of such having taken place. A collection of such facts, compared with similar instances on other coasts, would furnish an interesting subject of investigation, and would tend to the promotion of that science which it is the object your Society to cultivate.

2.—*Notice of Pseudomorphous crystals of oxide of tin, found in Huel Coates mine, in St. Agnes, in the year* 1828.

Communicated by

STEPHEN DAVEY, Esq.

Huel Coates is an ancient tin-mine, situated about three hundred fathoms north-west of St. Agnes Beacon. The adit level is about fifty-five fathoms below the surface, and five fathoms above high water-mark. The mine has never been worked more than a few feet below this level.

The crystals in question were discovered in a small vein (composed principally of light red sand) whose usual width is not more than three inches; but just at this spot it becomes enlarged to twelve inches: they were first discovered about three fathoms above the adit, and continued in the vein to the height of six fathoms, and for two or three fathoms in length; here the small vein was intersected by a large one, about three feet wide, (composed of ire-stone and sand, underlying northward about three feet in the fathom) which *heaved* it; and, as the mine has not since been much explored, the vein containing the tin crystals has not been discovered on the other side of the larger vein.

The crystals have generally the usual form of felspar crystals: the most common is that of a flattened rhomboid with the angles deeply replaced; they frequently cross and overlap each other. The quantity of tin contained in them varies greatly, some containing only ten, and others as much as seventy-five per cent. Many appear as if they had been broken, and the pieces afterwards cemented together by minute crystals of tin.

The crystals first found were small and imperfect; but they increased in size, and became better defined as they approached the centre of the bunch; but from this point a gradual decline took place, until they nearly corresponded with those first discovered.

The veins or lodes of Huel Coates are in soft or decomposed granite or elvan. In this substance similar crystals of a kind of sandstone have been found, containing no tin: these occurred on the north of the small vein, for the space of two feet in width, and fifty fathoms in length.

3.—*Notice of some Records having reference to the commencement of Copper Mining in Cornwall and Devon.*

Communicated by

GEORGE S. BORLASE, Esq. F.R.S.

The opinion expressed in a former communication to this Society* that copper was not raised to any extent within the county of Cornwall, before the latter part of the sixteenth century, and that a few individuals only were acquainted with the value of copper-ore, and profited by their knowledge, is most probably correct; but although there are not records of the production of copper, or of the existence of copper mines, yet I am inclined to think, from various grants for searching for copper in the counties of Cornwall and Devon, (i. e. within the Stannaries) which have not been noticed by our historians, that the yellow and grey ores were known at a much earlier period, and no doubt raised in small quantities, either by separation from the tin or from copper-lodes.†

* Mr. Carne on Copper Mines, Vol. III. page 44.

† Pearce on the Stannaries says, "the reason why copper was so little sought for in Cornwall was that the wood and turf were required for tin."

The earliest grant that I have seen was made in 32nd. Edward III. A.D. 1359, to John Ballancer and Walter Golboter, for two years, of all mines of gold, silver, and *copper*, in the county of Devon, which can be found in the mountains, in the fields, or desert places; but not in gardens, nor under houses: and in case it should be necessary to cut down any trees for the working of the mines, that they should pay the proprietors. And for the same mines they shall pay to the King twenty marks for the first year, and for the second year the fifth part of the gold, silver, and *copper*, that shall come from the same mines; and no other person during the term shall be allowed to dig for the same.

Henry VI. by letters patent, in the seventeenth year of his reign, (A.D. 1439,) given at the manor of Shene, granted certain mines in the counties of Cornwall and Devon, to John Sollers; and by his letters patent, given at Westminster in the thirtieth year of his reign, made a similar grant to John Bottright, of all his mines of gold, silver, *copper*, brass and lead, and of all other minerals in the said two counties.

In the thirty-first year of the same reign there was another grant to the same John Bottright, Professor of Theology, who was then Prefect and Governor of all the King's mines, giving him the exclusive right of working all mines in Cornwall and Devon:* and in his thirty-fourth year, he granted to

* Tin mines always excepted, they having been granted to the Duke of Cornwall by Edward III. In the same year with this grant, Edward, the son of Henry VI. was born.

Alured Coroneborough, Comptroller of all mines in the county of Cornwall, the power to dig in any mine in which was any gold, silver, or *copper;* or from whence any could be extracted.

In the second Edward IV. liberty was given to three men to search for tin, *copper,* and lead, in the counties of Somerset and Gloucester. In those counties no ores of tin have ever been found; and of copper, only a small quantity has yet been discovered; but unless some profits had been reported to have been made by the lessees of the Crown, in the western counties, it is not very probable that these adventurers would have embarked in such a speculation.

The preceding grants are given in the order in which they are cited in a curious case,* tried at bar, in the tenth year of the reign of Queen Elizabeth, respecting the right of the Crown to all mines;† in which report it appears that permission had been given to several persons to search for *copper* in other counties, and grants are there set forth.

No account can be obtained of the copper mines that were actually worked, (the grant to John Sollers being of *certain mines* only) nor of the quantity or quality of the copper produced in the two counties; but it is not, I think, reasonable to suppose that so many letters patent would have been solicited unless

* Plowden's Commentaries, fol. page 317.

† One argument used for the claim by the Crown of "all mines" was, that as it was entitled to all gold and silver, it was consequently entitled to work all veins to find the same; and that if one quillful only of gold were found, the whole mine belonged of right to the Crown, as more gold might be discovered.

the grantees had ascertained the existence of copper-ore. Whether any, and what, returns were made to the Crown cannot now be ascertained from the records in the Exchequer, where diligent search has been expressly made; yet from the preceding grants I venture to assign the commencement of the working of copper mines, and the separation of that ore from the tin-stuff, to the reign of Edward III. as early as the middle of the fourteenth century; and I think that I am warranted in naming that precise period; for had any previous grants been in existence, they would have been cited in the case to which I have alluded in order to strengthen the claims of the Crown.

4.—*Notice of the Work performed by the Steam-Engines in the Mines of Cornwall.*

In the notice No. 4, inserted in the third volume of Transactions, it appeared that the average work performed by the Steam Engines, employed in drawing water out of the mines of Cornwall, in August, 1827, was the lifting 33,132,600 pounds, one foot high, by the consumption of a bushel of coal.

The following account for every month in the year 1831, will shew how greatly these machines have been improved, and their work consequently encreased, since that period.

		No. of Engines.	Average.	Maximum.
January	—	50	45,498,907	80,088,580
February	—	51	45,776,260	75,797,535
March	—	50	46,264,772	74,007,519
April	—	45	48,632,085	76,036,153
May	—	49	46,083,316	71,052,036
June	—	49	46,470,825	76,621,016
July	—	55	41,915,031	77,343,947
August	—	54	46,048,535	72,958,254
September	—	58	43,357,625	71,087,231
October	—	62	41,966,312	72,016,126
November	—	60	41,273,330	77,282,529
December	—	62	42,580,039	74,646,362

5.—*Notice of the Quantity of Tin raised in Cornwall and Devon.*

	1827.		1828.		1829.		1830.		1831.	
	BLOCKS.		BLOCKS.		BLOCKS.		BLOCKS.		BLOCKS.	
	Common	Grain	Common	Grain	Common	Grain	Common	Grain	Common	Grain
Ladyday Quarter	6283	542	6199	280	5580	224	5239	185	5681	271
Midsummer Quarter	8158	531	6150	351	5342	389	6366	730	6320	485
Michaelmas Quarter	7704	293	7634	676	7391	532	5941	513	5045	338
Christmas Quarter	7320	374	5818	485	5206	126	5554	324	5760	265
Cornwall	29465	1740	25801	1792	23159	1271	23100	1752	22806	1359
Devonshire	501	39	522	64	410	137	493	47	388	15
Blocks	31744		28179		25337		25392		24568	
Tons	5400		4800		4280		4320		4176	

An Account of the Produce of the Copper Mines of Cornwall in Ore, Copper, and Money, in the Year ending the 30th June, 1828.

	Tons of Ore.		Tons of Copper.		£
Consolidated Mines	13,879	....	1,265	....	101,008
Penstruthal	10,295	....	650	....	48,645
Dolcoath	9,012	....	631	....	49,070
East Crinnis	8,057	....	618	....	44,180
Lanescot	7,500	....	604	....	41,248
Poldice and Huel Unity	4,516	....	381	....	30,458
Fowey Consols	4,216	....	340	....	23,494
Huel Buller & Beauchamp	5,197	....	304	....	22,445
Pembroke	4,209	....	277	....	20,064
H. Montague & Harmony	2,348	....	273	....	22,405
Binner Downs	3,986	....	265	....	20,486
Herland	2,151	....	229	....	18,655
Huel Damsel	2,186	....	215	....	17,365
Huel Busy	3,881	....	214	....	15,470
North Roskear	3,285	....	213	....	16,226
Huel Gorland	2,870	....	204	....	15,666
Huel Towan	3,337	....	203	....	15,258
Huel Trenwith	1,427	....	194	....	16,191
Tingtang	2,463	....	194	....	15,071
Huel Maiden & Carharrack	2,519	....	177	....	13,745
Huel Chance Consols	2,055	....	176	....	13,560
Tresavean	1,714	....	159	....	12,699
Huel Tolgus	1,290	....	156	....	12,980
Huel Caroline	2,400	....	156	....	11,851
Cook's Kitchen	2,490	....	139	....	10,276
Stray Park	1,798	....	118	....	9,095
United Mines	1,384	....	111	....	8,545
Huel Hope	952	....	99	....	8,107
Great St. George	1,624	....	97	....	6,915
Carzize	952	....	90	....	7,243
Crinnis Consols	1,326	....	89	....	6,380
North Downs	970	....	80	....	6,185
Huel Chance	752	....	70	....	5,529
Huel Rodney	1,150	....	70	....	5,256
Levant	581	....	58	....	4,496
Huel Charlotte	886	....	57	....	4,118
United Hills	945	....	53	....	3,835
Huel Trannack	763	....	51	....	3,810
Mines under Fifty Tons	9,000	....	641	....	48,145
Private Contracts	500	....	40	....	3,000
	130,866		9,961		759,175

Average Standard, £112 7*s*. Average Produce 7⅞.
Average Price per Ton of Ore, £5 16*s*.

An Account of the Produce of the Copper Mines of Cornwall in Ore, Copper, and Money, in the Year ending the 30th June, 1829.

	Tons of Ore.		Tons of Copper.		£
Consolidated Mines	12,576	....	1,134	....	88,171
Dolcoath	8,890	....	720	....	55,469
Lanescot	7,864	....	627	....	41,499
East Crinnis	7,958	....	557	....	40,311
Poldice and Huel Unity	5,289	....	407	....	31,041
Fowey Consols	4,859	....	378	....	24,773
Huel Leisure	2,999	....	350	....	27,081
Tresavean	2,656	....	287	....	22,590
Binner Downs	4,062	....	279	....	20,751
North Roskear	3,815	....	278	....	20,973
Tingtang	3,555	....	269	....	20,455
Huel Buller	4,459	....	268	....	19,443
Pembroke	3,645	....	260	....	18,519
Huel Trenwith	2,062	....	236	....	18,701
Herland	2,202	....	235	....	18,657
Huel Towan	3,784	....	229	....	16,687
Penstruthal	4,678	....	227	....	15,475
Huel Gorland	2,572	....	184	....	13,950
Stray Park	2,384	....	181	....	13,735
Huel Damsel	1,844	....	178	....	13,969
H. Montague & Harmony	1,881	....	171	....	13,291
Huel Caroline	2,149	....	139	....	10,315
Huel Tolgus	1,293	....	132	....	10,393
Huel Busy	2,423	....	130	....	9,251
United Mines	1,482	....	119	....	9,108
Huel Hope	1,011	....	118	....	9,445
Levant	850	....	96	....	7,067
Huel Maiden & Carharrack	1,117	....	93	....	7,082
Crinnis Consols	1,719	....	92	....	6,080
Cook's Kitchen	1,544	....	89	....	6,419
Great St. George	1,339	....	83	....	5,842
Huel Charles	1,215	....	82	....	6,074
Huel Mary	1,314	....	73	....	5,172
North Downs	792	....	70	....	5,442
Huel Trannack	1,100	....	69	....	4,871
United Hills	978	....	59	....	4,194
Botallack	500	....	54	....	3,980
Cardrew	708	....	52	....	3,945
Mines under Fifty Tons	8,934	....	652	....	47,113
Private Contracts	1,400	....	106	....	8,500
	125,902		9,763		725,834

Average Standard, £ 109 14*s.* Average Produce, 7¾.
Average Price per Ton of Ore, £ 5 15*s.* 6*d.*

An Account of the Produce of the Copper Mines of Cornwall in Ore, Copper, and Money, in the Year ending the 30th June, 1830.

	Tons of Ore.		Tons of Copper.		£
Consolidated Mines	12,884	....	1,203	....	89,907
Dolcoath	11,213	....	867	....	64,145
Huel Leisure	8,504	....	782	....	56,000
Fowey Consols	7,085	....	562	....	36,696
North Roskear	5,548	....	550	....	41,286
East Crinnis	7,576	....	518	....	34,631
Lanescot	6,152	....	498	....	32,648
Tresavean	4,594	....	458	....	34,176
Poldice and Huel Unity	4,725	....	385	....	28,608
Binner Downs	4,243	....	319	....	23,294
Tingtang	4,310	....	307	....	22,321
Pembroke	4,175	....	299	....	20,574
Herland	2,202	....	243	....	18,720
Huel Towan	3,576	....	210	....	14,533
Huel Jewel	1,649	....	209	....	15,858
Huel Buller	3,487	....	207	....	14,772
Great St. George	1,565	....	195	....	14,352
Levant	1,246	....	173	....	12,848
Huel Damsel	1,723	....	165	....	12,471
Huel Gorland	1,989	....	151	....	10,967
Huel Trenwith	1,571	....	149	....	11,174
Huel Tolgus	1,324	....	136	....	10,354
United Mines	1,159	....	124	....	9,382
Stray Park	1,762	....	124	....	9,057
H. Montague & Harmony	1,378	....	121	....	9,013
Penstruthal	2,516	....	120	....	7,917
Huel Maiden & Carharrack	1,243	....	111	....	8,316
Huel Caroline	1,762	....	110	....	7,826
Cardrew	1,594	....	107	....	7,558
Huel Trannack	1,671	....	104	....	7,222
Cook's Kitchen	2,171	....	90	....	5,755
Huel Hope	812	....	84	....	6,390
Huel Sperris	2,273	....	84	....	4,963
United Hills	1,269	....	77	....	5,423
Huel Charles	1,225	....	72	....	5,035
Botallack	595	....	71	....	5,266
Huel Mary Consols	849	....	70	....	5,030
Huel Cock	526	....	56	....	4,149
Mines under Fifty Tons	9,759	....	638	....	45,209
Private Contracts	1,760	....	141	....	10,150
	135,665		10,890		784,000

Average Standard £106 5*s*. Average Produce 8.
Average Price per Ton of Ore £5 15*s*. 6*d*.

An Account of the Produce of the Copper Mines of Cornwall in Ore, Copper, and Money, in the Year ending the 30th June, 1831.

	Tons of Ore.		Tons of Copper.		£
Consolidated Mines	14,873	....	1,384	....	95,666
Dolcoath	11,652	....	904	....	61,607
Fowey Consols	8,345	....	686	....	43,312
Tresavean	6,699	....	666	....	45,797
Huel Leisure	9,627	....	652	....	40,433
Huel Tolgus	5,286	....	620	....	43,906
Huel Jewel	4,061	....	526	....	38,005
North Roskear	5,893	....	518	....	35,398
East Crinnis	6,641	....	481	....	30,017
Great St. George	3,964	....	458	....	31,350
Pembroke	4,060	....	451	....	30,883
Laneseot	4,554	....	389	....	24,828
Poldice and Huel Unity	3,756	....	354	....	24,459
Binner Downs	4,305	....	328	....	22,437
Penstruthal	5,554	....	285	....	17,161
Marazion Mines	3,338	....	248	....	16,538
Herland	1,962	....	225	....	16,052
Tingtang	2,767	....	223	....	15,108
Huel Towan	3,502	....	208	....	13,104
Levant	1,290	....	192	....	13,523
Stray Park	2,344	....	164	....	10,962
Huel Buller	2,379	....	159	....	10,458
Huel Gorland	1,745	....	141	....	9,708
United Mines	1,369	....	129	....	8,889
Huel Trenwith	1,061	....	121	....	8,502
Huel Strawberry	1,840	....	113	....	7,287
Huel Maiden & Carharrack	1,103	....	100	....	6,865
Huel Damsel	1,364	....	98	....	6,619
Cook's Kitchen	2,021	....	98	....	5,871
Huel Mary	1,385	....	97	....	6,323
Huel Caroline	1,144	....	70	....	4,511
H. Montague & Harmony	792	....	66	....	4,509
Cardrew	946	....	64	....	4,167
Mines under Fifty Tons	12,780	....	826	....	51,835
Private Contracts	2,100	....	174	....	11,650
	146,502		12,218		817,740

Average Standard £99 18*s.* Average Produce 8¾.
Average Price per Ton of Ore £5 11*s.* 6*d.*

An Account of the Produce of the Copper Mines of Cornwall in Ore, Copper, and Money, in the Year ending the 30th June, 1832.

	Tons of Ore.		Tons of Copper.		£
Consolidated Mines	15,523	....	1,530	....	108,886
Tresavean	8,178	....	894	....	63,824
Dolcoath	9,682	....	779	....	54,272
Fowey Consols	8,099	....	665	....	43,755
North Roskear	7,419	....	652	....	45,500
Huel Tolgus	4,930	....	597	....	43,313
Huel Leisure	7,479	....	504	....	32,227
Pembroke	3,797	....	458	....	32,559
Great St. George	3,695	....	421	....	29,535
Marazion Mines	5,408	....	400	....	27,118
Huel Jewel	3,701	....	376	....	26,704
East Crinnis	4,485	....	352	....	22,946
Binner Downs	4,326	....	348	....	24,365
Lanescot	3,684	....	329	....	22,090
Poldice and Huel Unity	3,069	....	271	....	18,935
Penstruthal	5,327	....	268	....	16,241
Retallack	2,219	....	240	....	17,224
Levant	1,188	....	210	....	15,302
Huel Elizabeth	2,908	....	170	....	11,194
Cardrew Consols	2,108	....	166	....	11,431
United Mines	1,470	....	160	....	11,600
Herland	1,383	....	155	....	11,215
Huel Towan	2,431	....	154	....	10,099
Tingtang	1,808	....	140	....	9,656
Huel Buller, &c.	1,633	....	121	....	8,163
Huel Mary	1,596	....	119	....	8,030
Stray Park	1,475	....	105	....	7,245
Huel Strawberry	1,758	....	105	....	6,923
Huel Gorland	1,098	....	97	....	6,915
Cook's Kitchen	1,833	....	96	....	6,100
Huel Damsel	1,089	....	95	....	6,622
Huel Trenwith	661	....	85	....	6,240
Huel Maiden, &c.	969	....	84	....	5,831
United Hills	870	....	73	....	5,088
Huel Busy	1,382	....	68	....	4,150
South Towan	1,187	....	67	....	4,352
South Roskear	595	....	57	....	4,034
Huel Unity Wood	552	....	56	....	3,987
Botallack	377	....	56	....	3,960
Mines under Fifty Tons	5,992	....	425	....	27,981
Private Contracts	1,700	....	151	....	10,200
	139,057		12,099		835,812

Aver. Stan. £ 100 14*s*. Aver. Pro. 8¾. Aver. Price per Ton of Ore £6.

Quantity of Copper produced in Great Britain and Ireland.

To 30th June,	1828.	1829.	1830.	1831.	1832.
	Tons.	Tons.	Tons.	Tons.	Tons.
Cornwall	9961	9763	10890	12218	12099
Devonshire	434	318	368	312	249
Other parts of England	71	36	10	31	42
Anglesea	738	901	815	809	852
Other parts of Wales	259	172	237	123	237
Ireland	706	790	768	972	974
Isle of Man	——	14	9	15	12
	12169	11994	13097	14480	14465
From Foreign Ore	——	30	124	100	56

Purchasers of the Copper-Ores of Great Britain and Ireland.

	1828.	1829.	1830.	1831.	1832.
	Tons.	Tons.	Tons.	Tons.	Tons.
Mines Royal Co.	262	225	422	367	367
English Co.	887	812	546	629	632
Birmingham Co.	978	986	893	1003	743
Vivian and Sons	1943	1876	2112	2869	3065
Freeman and Co.	736	928	822	1129	1087
Williams, Grenfell, & Co.	1546	787	——	——	——
P. Grenfell, and Co.	——	366	1698	1515	1520
O. Williams	——	115	473	341	239
Crown Co.	984	956	1015	1031	1065
Daniell, Nevill, and Co.	1670	1616	1838	1813	1717
Williams, Foster, & Co.	1761	2045	2102	2310	1882
Shears and Sons	664	510	320	162	——
Usborne (Forest) & Co.	——	110	215	389	1054
Glascott and Co.	——	——	——	213	252
G. Wildes and Co.	——	——	——	——	46
Anglesea Co. (smelted)	738	692	765	809	852
	12169	12024	13221	14580	14521

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